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SUPPLEMENT
TEST REPORT
GUN FIRING SHOCK
AND
ROAD VIBRATION

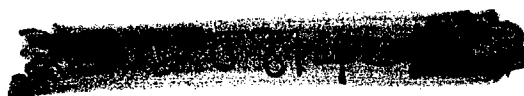
M60A1 (P1) TANK THERMAL SIGHT (TTS)
AN/VSG-2 PROTOTYPE QUALIFICATION

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PREPARED FOR
ARMY MATERIEL COMMAND
PROJECT MANAGER-M60 TANKS
BY

DEFENSE DIVISION
CHRYSLER CORPORATION

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SUPPLEMENT
TEST REPORT
GUN FIRING SHOCK
AND
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M60A1 (P1) TANK THERMAL SIGHT (TTS)
AN/VSG-2 PROTOTYPE QUALIFICATION

REQUESTED BY:

A. Abrew

CONTRACT NUMBER:

DAAK30-76-C-0005

WORK DIRECTIVE NO:

KX-2104

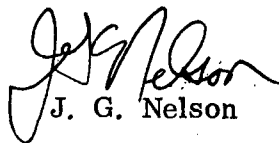
CONTRACT DATA ITEM NO:

DI-T-1906

DATE:

5 December 1977

PREPARED BY:


J. G. Nelson

APPROVED BY:

P. PERANI, Manager
Reliability Test and
Materials Section

PREPARED FOR
U. S. ARMY TANK-AUTOMOTIVE MATERIEL READINESS COMMAND
PROJECT MANAGER - M60 TANK DEVELOPMENT
BY
WARREN DEFENSE DIVISION
CHRYSLER CORPORATION

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1.0 BACKGROUND

The tank thermal sight (TTS) vastly improves night target acquisition and identification under normal and adverse atmospheric conditions.

The incorporation of the tank thermal sight into the M60A1 Weapon systems, requires the establishment of a baseline level for gun firing shock, hard surface/cross country road vibration. These levels are required to determine the design adequacy of the components and mounting bracketry used in the TTS system.

2.0 TEST OBJECTIVES

The object of this test program is to evaluate the compatibility of the M60 series tank, with that of the installed components and bracketry of the TTS system, during the firing of the main gun, and a road imposed shock/vibration environment.

In order to ascertain these baseline compatibility levels a test program is required to determine the three axis magnitude of the imposed gun shock/road vibration environment at the following tank locations.

1. Base of the gunner's TTS periscope - response of gunner's scope.
2. TTS periscope head - response of periscope head.
3. Turret roof adjacent to gunner's periscope mounting - input to the gunner's scope.
4. Turret right wall, between commander's TTS light elbow mounting pads - turret wall input.
5. Flange on TTS light elbow - response to the turret wall input.
6. No-bak housing - input to TTS light elbow @ the commander's viewer.
7. Commander's viewer mounting bracket - response to the no-bak mounting.
8. Turret bustle roof - input to TTS power converter.
9. Power converter housing - response to the TTS converter mounting.

A pictorial presentation of the selected mounting locations for the accelerometers are shown in attached Figures 1 thru 3.

3.0 CONCLUSIONS

1. All of the TTS interface vibration levels were below the TTS component vibration levels specified for TTS component qualification test.

2. Except for PQ1 No-Bak/TTS light elbow interface, all gun shock levels were below the TTS component shock levels specified for TTS component qualification test. The discrepancy between PQ1 and PQ2 no-bak input level is unexplained. The PQ1 no-bak real time gun shock signatures indicated the presence of high frequency data (1-2 KHz) that was not observed on the test firings on PQ2. A possible explanation of this high frequency component noted on PQ1 could have been, difference in vehicle component structure, component alignment and/or mounting methods (bolt torque). In subsequent check of vehicle logs, a loose ball joint bolt and image intensifier tube was reported on PQ1 four days after the main gun firing tests.

4.0 RECOMMENDATIONS

The results of three (3) previous TTS/main gun firing shock tests have indicated that the shock level as specified in the interface control document (TD137989) are realistic. The levels recorded on PQ1 no-bak, have been the only substantial deviation noted from any of the TTS gun shock tests. No changes are recommended to the interface control document.

5.0 TEST PROCEDURE

In both test phases, road vibration and gun shock, the test vehicle used were two fully functional M60A1 (P1) tanks with standard suspension with T-142 track, and incorporating the tank thermal sight system (TTS).

Road vibration testing (both hard surface, cross country) and main gun firing shock testing was accomplished at Fort Knox during the PQT-C qualification test program.

5.1 Phase I Gun Firing Shock

The instrumentation setup for the shock data collection is shown in Figure 4. The gun firing shock acceleration datum was recorded on magnetic tape, and then played back into an analog-to-digital converter and re-recorded on digital computer tape, for computer analysis. This data was digitized at 16 KHz/sec for 128 milliseconds. To prevent aliasing in the digital signal, all channels of data were filtered prior to digitizing by a 2500 Hertz low pass filter. This digitized data was then processed as a shock response spectrum, and plotted as equivalent static acceleration (Max G's). For this analysis, the maximum spectrum using one percent damping, was computed at 40 frequency points corresponding to 15 to the decade. For every acceleration time trace, a shock response spectrum (ESA) was computed. Mean & mean + three standard deviations shock spectrum were computed for multiple round firings with same configuration (sensing axis and accelerometer location).

5.2 Phase II Hard Surface & Cross Country Vibration

The two instrumented M60A3 vehicles used in the gun firing shock test, (Figure 1 thru 3) were also utilized for this vibration testing. The instrumentation setup for both the hard surface and cross country vibration is shown in Figure 5.

Data acquisition was accomplished while the vehicle operated under the following test conditions.

1. Paved Surface (PQ1 and PQ2)
 - A. Constant speeds of 5, 10, 15, 20 and 25 mph
 - B. 0-Max-0 mph acceleration/deceleration
2. Cross Country (PQ2)
 - A. Ten (10) minutes of variable speed operation

*NOTE: Conditions 1 was performed in both with and without the TTS Light elbow to determine the effects of elbow on the No-bak housing vibrations levels.

The resulting tape recorded data was processed using a Spectral Dynamics (Model SD330) real time analyzer to provide two (2) power spectra density plots for each speed/condition. The lower plot is an ensemble average for 32 seconds (64 averages) of real time. The upper plot is the maximum value (peak) obtained for this same 32 second sample. For the cross-country plots the average time was increased to 256 seconds (512 averages) of real time.

6.0 TEST RESULTS AND DISCUSSION

The presentation of the test results and their discussion are separated into Vibration Results and main gun-firing shock results.

6.1 Main Gun Firing Shock Results

The equivalent static acceleration plots of the gun firing shock analysis are presented in Appendix 1.

The half sine pulse values for fits to the mean + 3 sigma ESA curves are tabulated in Tables 1 & 2 for each of the test vehicles. A comparison of the environment specification level with that of the field obtained gun shock levels indicated that the specification levels are larger than that of the field obtained levels, except for PQ1 Location #5 the No-bak input. The shock amplitude recorded at the No-bak (all axes) during the gun firing of PQ1 was the most severe noted in any of the gun firing shock testing. This shock level (approx. 1000 g @ .5 ms) was not repeatable in the gun firing of PQ2 using the same shock instrumentation measuring equipment and under like weather condition with the exception of rain on PQ2 firing day. This high shock level recorded from the No-bak input on PQ1 is considered to be valid data and at this time the high shock levels recorded are unexplained.

6.2 Hard Surface & Cross Country Vibration

The power spectral density plots for the hard surface & cross-country vibration are contained in Appendix 2.

Two (2) power spectral density plots are presented for each speed/condition. The lower plot being an ensembled average of 32 seconds of real time and the upper plot the maximum value obtained for the same 32 second sample. Since the data is presented in power spectral density format (g^2/Hertz) and the interface specification reference MIL-STD-810B, vibration method 514.1 procedure VIII, curve W, for ground test vehicles in sine sweep format, the following conversion can be used:

$$G \text{ Max} = \sqrt{\frac{2 (\text{PSD}) \times \text{EBW}}{\text{QPD}}}$$

$$\text{Grms} = \sqrt{\frac{\text{PSD} \times \text{EBW}}{\text{QPD}}}$$

Where: PSD = Power spectrum density value in g^2/Hz

EBW = effective band width of spectrum analyzer

(3.25 for the 500 Hz range)

QPD = factor reflecting the quasi-peak detection process of the spectrum analyzer (1.12 for the SD330 model)

*NOTE: Figure 6 supplied the logarithmic scale conversion curves based on this formula that can be used for the g-levels at any point on the PSD plots.

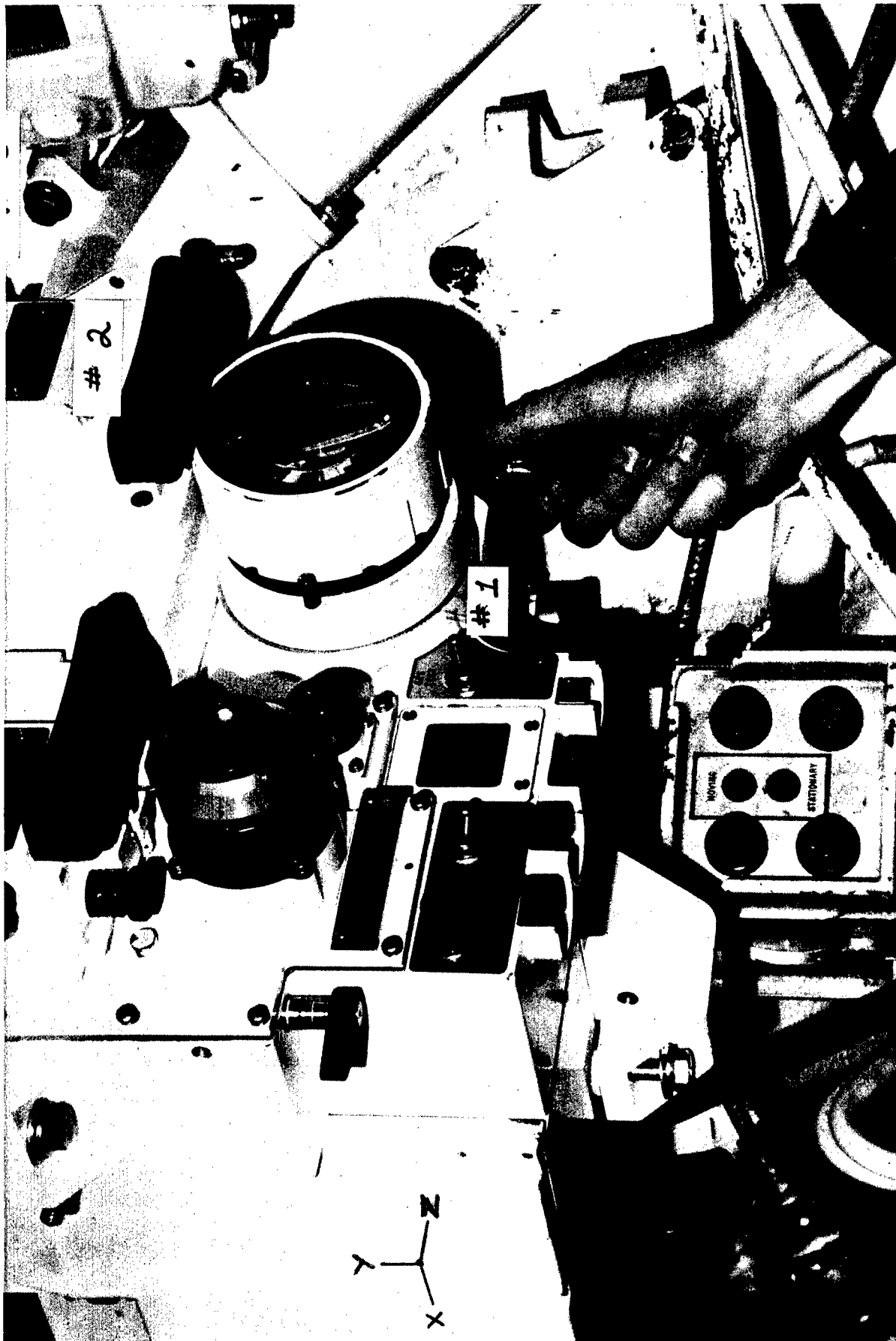
The resulting vibration test data (PSD plots) supply us with the following test results condition:

1. Cross-country operation is not as severe (vibration wise) as hard surface road vibration.
2. The vibration levels recorded at the No-bak housing with the TTS light elbow or without show no apprecible change in levels.
3. The highest induced vibration level occurred at speed of 20 to 25 mph.
4. The highest equivalent sine g peak inputs recorded for the TTS system were:
 - A. Turret Roof input to periscope: 0.56 g, 50 Hz vertical axis (ensembled average). 1.8 g, 50 Hz vertical axis (maximum) for test vehicle PQ1.
 - B. No-bak housing input to TTS Flange Light Elbow: 1.0 g, 65 Hz, vertical axis (ensembled average) 1.8 g, 65 Hz vertical axis (maximum) on test vehicle PQ2.
 - C. Turret bustle roof input to power converter:

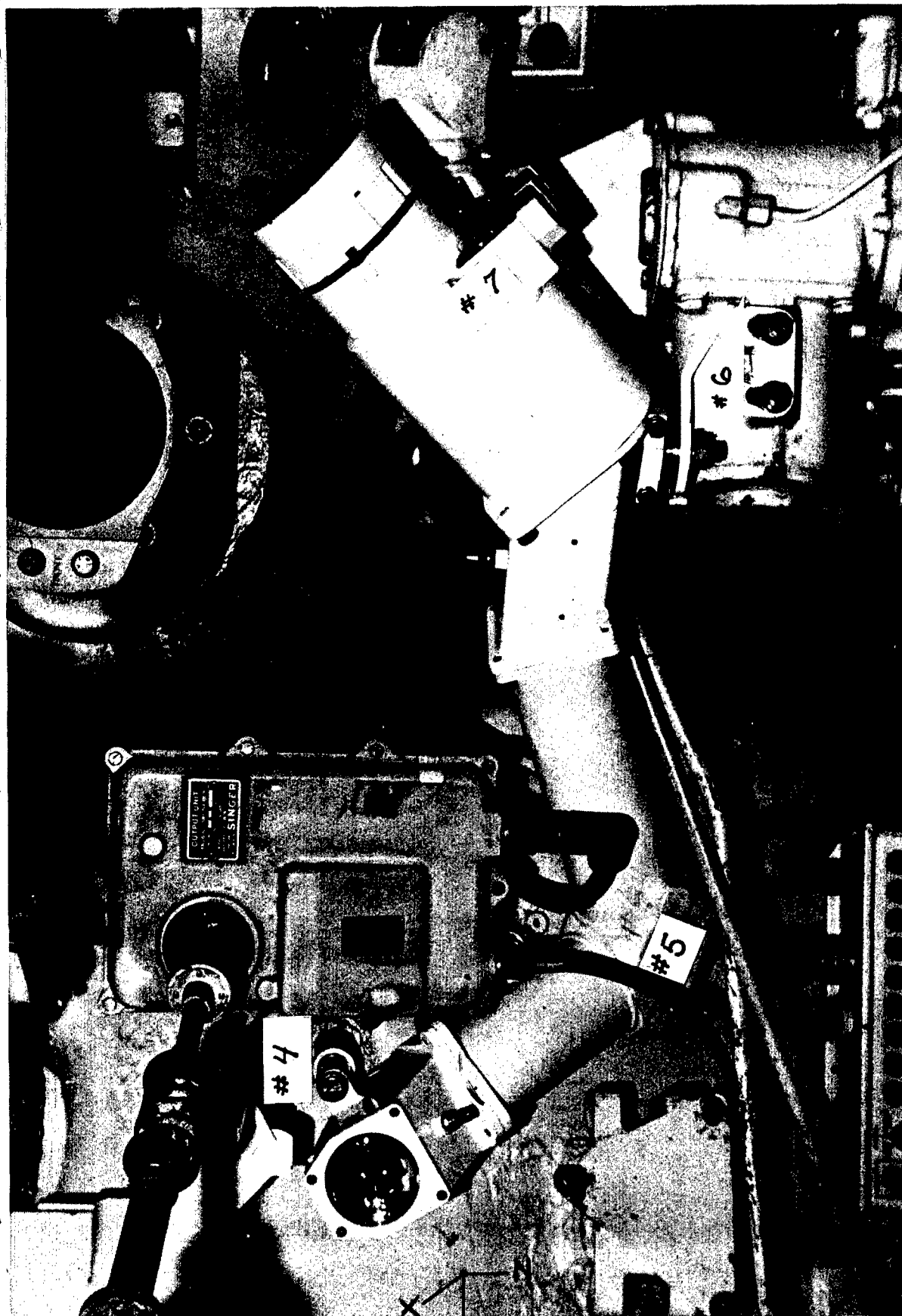
0.4 g, 50 Hz, transverse axis, (ensembled average)

0.85 g, 50 Hz transverse axis (maximum) on test vehicle PQ2.

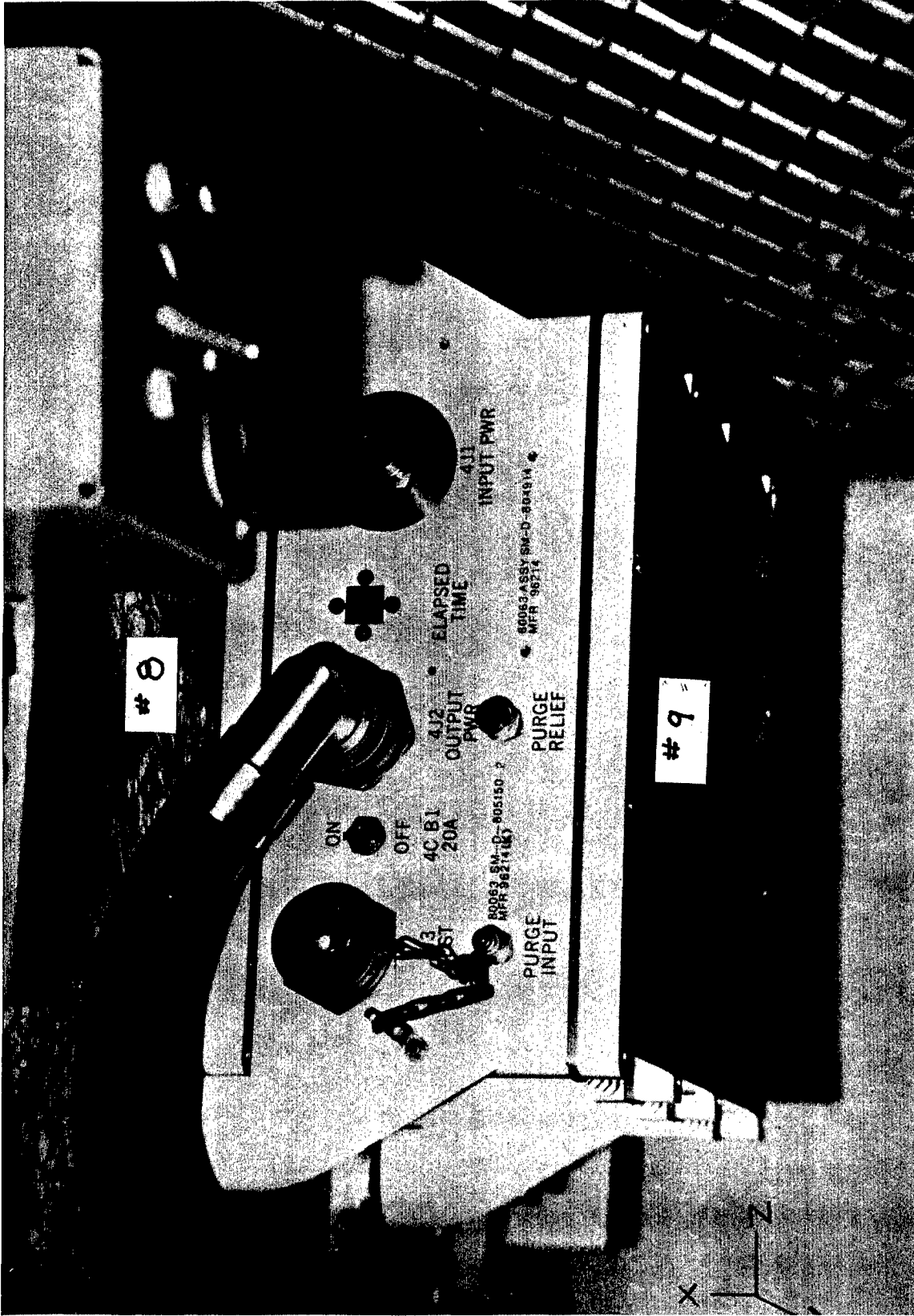
5. The highest equivalent sine g peak response recorded on the TTS system was at the commander viewer, a response from the no-bak housing input. The levels were 5.0 g, 65 Hz vertical axis (ensembled average) and 9.9 g, 65 Hz, vertical axis (maximum) on test vehicle PQ2.
6. The resulting vibration test data indicate that the interface spec for TTS vibration input levels (4 g's) was not exceeded in any of the test conditions.



#1 Base Gunners Periscope (Response to Turret Roof) #2 Periscope Head (Response to Turret Roof) #3 Turret Roof (Input to Periscope Base & Head)		
Prepared for:	ARMY MATERIEL COMMAND	
By:	CHRYSLER CORPORATION DEFENSE DIVISION	
	11-5-77 Date	77-1106 Negative

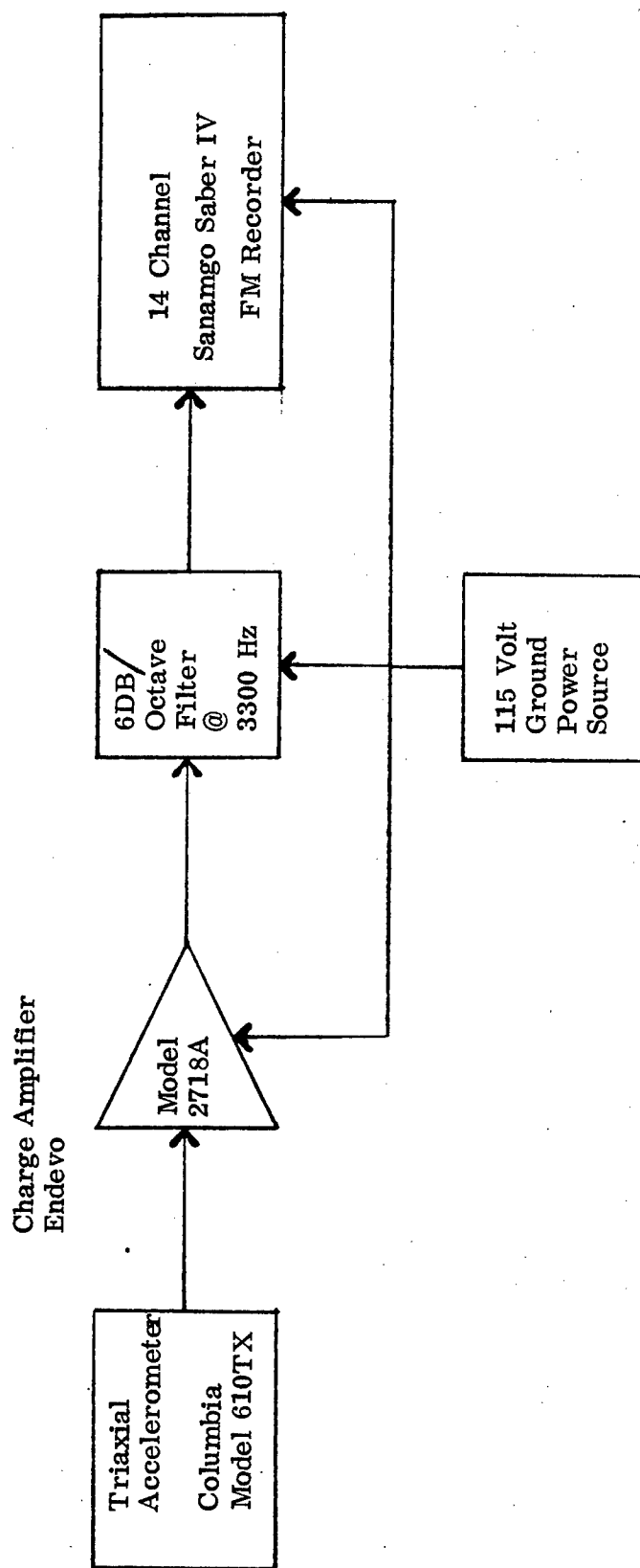


#4 Turret Right Wall (Input to Light Elbow)	#6 No-bak housing (Input Light Elbow)	
#5 Flange on Light Elbow (Response to Turret Wall)	#7 Commanders Viewer (Response to No-bak)	
Prepared for:	ARMY MATERIEL COMMAND	
By:	CHRYSLER CORPORATION DEFENSE DIVISION	
	11-5-77	77-1109
	Date	Negative



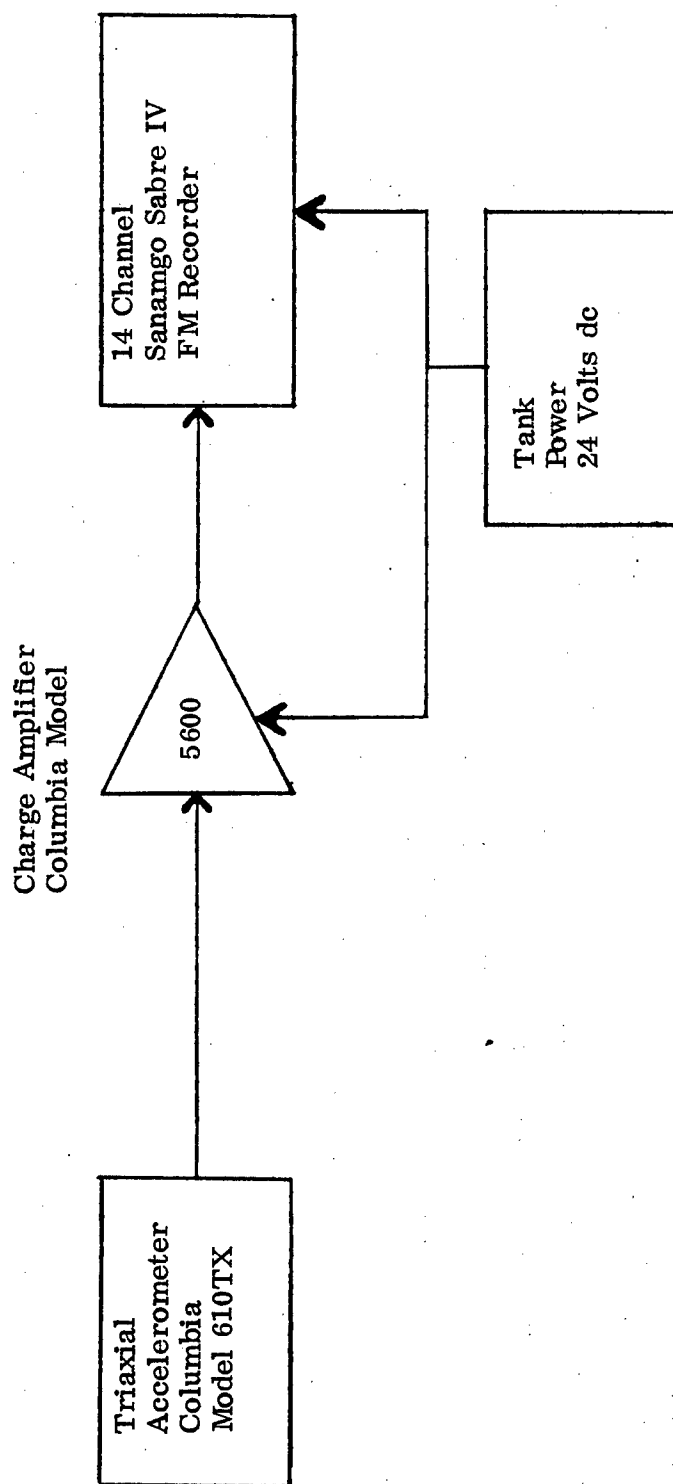
#8 Turret Bustle Roof (Input to Power Converter)		
#9 Power Converter Housing (Response to Bustle Roof)		
Prepared for:	ARMY MATERIEL COMMAND	77-1110
By:	CHRYSLER CORPORATION DEFENSE DIVISION	11-5-77 Date
		Negative

FIGURE 4

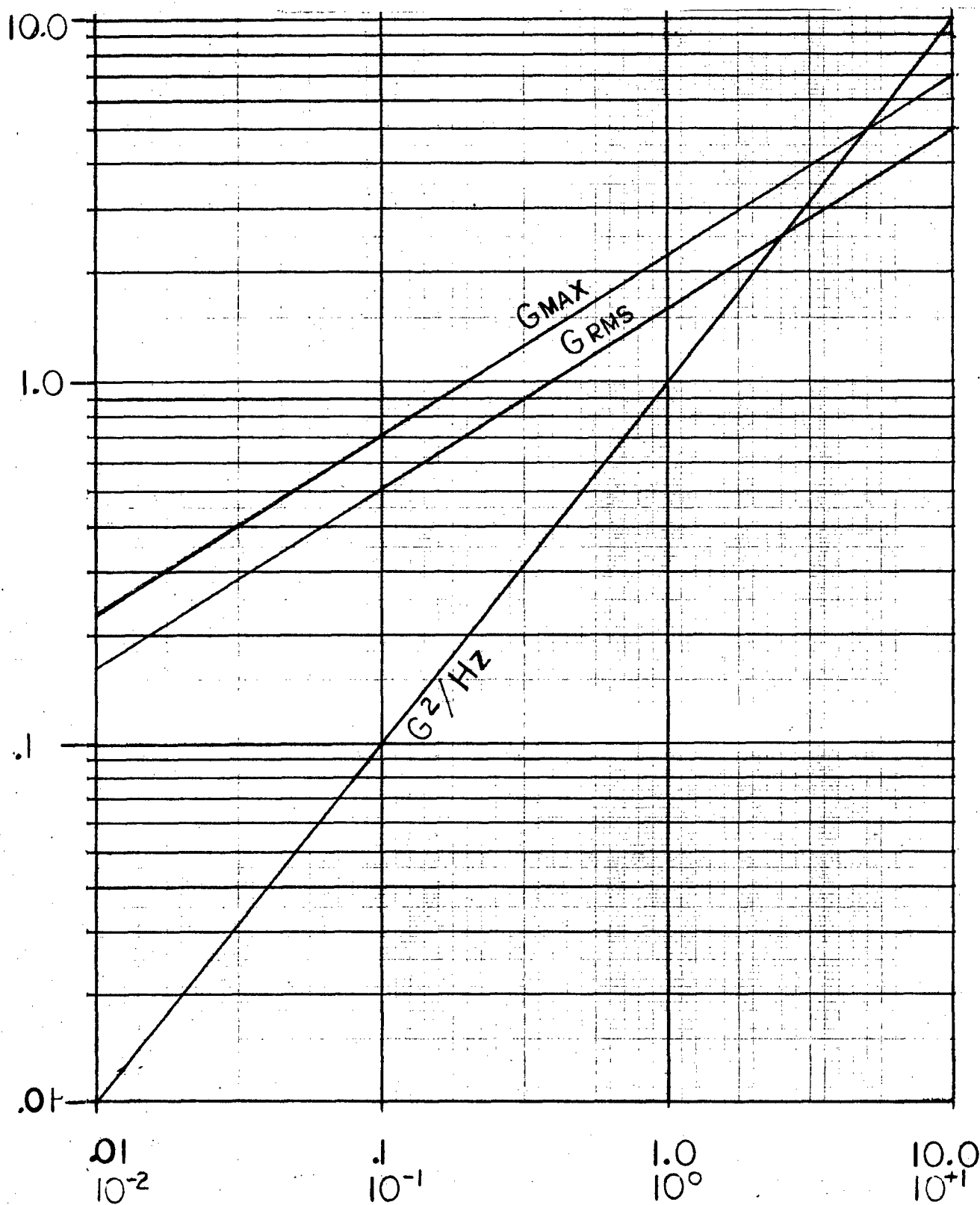


SHOCK INSTRUMENTATION DATA ACQUISITION SYSTEM

FIGURE 5



VIBRATION INSTRUMENTATION DATA ACQUISITION SYSTEM



LOGARITHMIC CONVERSION CURVES
OF POWER SPECTRUM DENSITY TO
HARMONIC VIBRATION G-LEVELS
FOR 0 TO 500 Hz RANGE

Figure 6

TABLE I
GUN FIRING SHOCK VALUES - HALF SINE PULSE - g, ms
PQ 1

Locations	Rounds Averaged	Mean + 3 Sigma	Interface		
			Trans	Long	Vert
1 Periscope base	(Response) 9	50g @ 4ms	50g @ 11ms	45g @ 3ms	Spec. Req'd
2 Periscope head	(Response) 9	100g @ 5ms	100g @ 1.8ms	100g @ 2ms	
3 Turret Roof	(Input to 1 & 2) 9	55g @ 1ms	52g @ 3ms	45g @ 1.8ms	100g @ 2ms
4 Turret Wall	(Input to 5 & 7) 9	38g @ 3ms	30g @ 3ms	12g @ 15ms	100g @ 2ms
5 TTS Flange	(Response) 8	100g @ 1.8ms	100g @ 2ms	105g @ 1.8ms	
6 No-bak Housing	(Input to 5 & 7) 5	1000g @ .5ms	1000g @ .5ms	1000g @ .5ms	100g @ 4ms
7 Commander's Viewer	(Response) 9	200g @ 4ms	100g @ .6ms	350g @ 1.3ms	
8 Turret Bustle Roof	(Input to 9) 9	35g @ 15ms	70g @ 2ms	100g @ 2ms	100g @ 2ms
9 TTS Pwr Converter	(Response) 9	80g @ 1.5ms	85g @ 3ms	200g @ 1.8ms	

TABLE II
GUN FIRING SHOCK VALUES - HALF SINE PULSE - g, ms
PQ 2

	Location	Rounds Averaged	Trans	Mean + 3 Sigma		Interface Spec. Req'd
				Long	Vert	
1	Periscope base	8	40g @ 3.9ms	55g @ 11ms	40g @ 2ms	
2	Periscope head	8	100g @ 1.3ms	100g @ 2ms	103g @ 7ms	
3	Turret Roof	8	65g @ 3ms	50g @ 5ms	45g @ 1.5ms	100g @ 2ms
4	Turret Wall (Right)	7	40g @ 4ms	35g @ 5ms	40g @ 18ms	100g @ 2ms
5	TTS Flange	6	90g @ 3ms	90g @ 6ms	70g @ 3.5ms	
6	No-bak Housing	5	80g @ 6ms	80g @ 4.5ms	80g @ 7ms	100g @ 4ms
7	Commander's Viewer	5	180g @ 13ms	90g @ 3ms	200g @ 3ms	
8	Turret Bustle Roof	8	30g @ 7.4ms	40g @ 21ms	70g @ 4.5ms	100g @ 2ms
9	TTS Pwr Converter	5	60g @ 1ms	100g @ 3ms	220g @ 1.5ms	

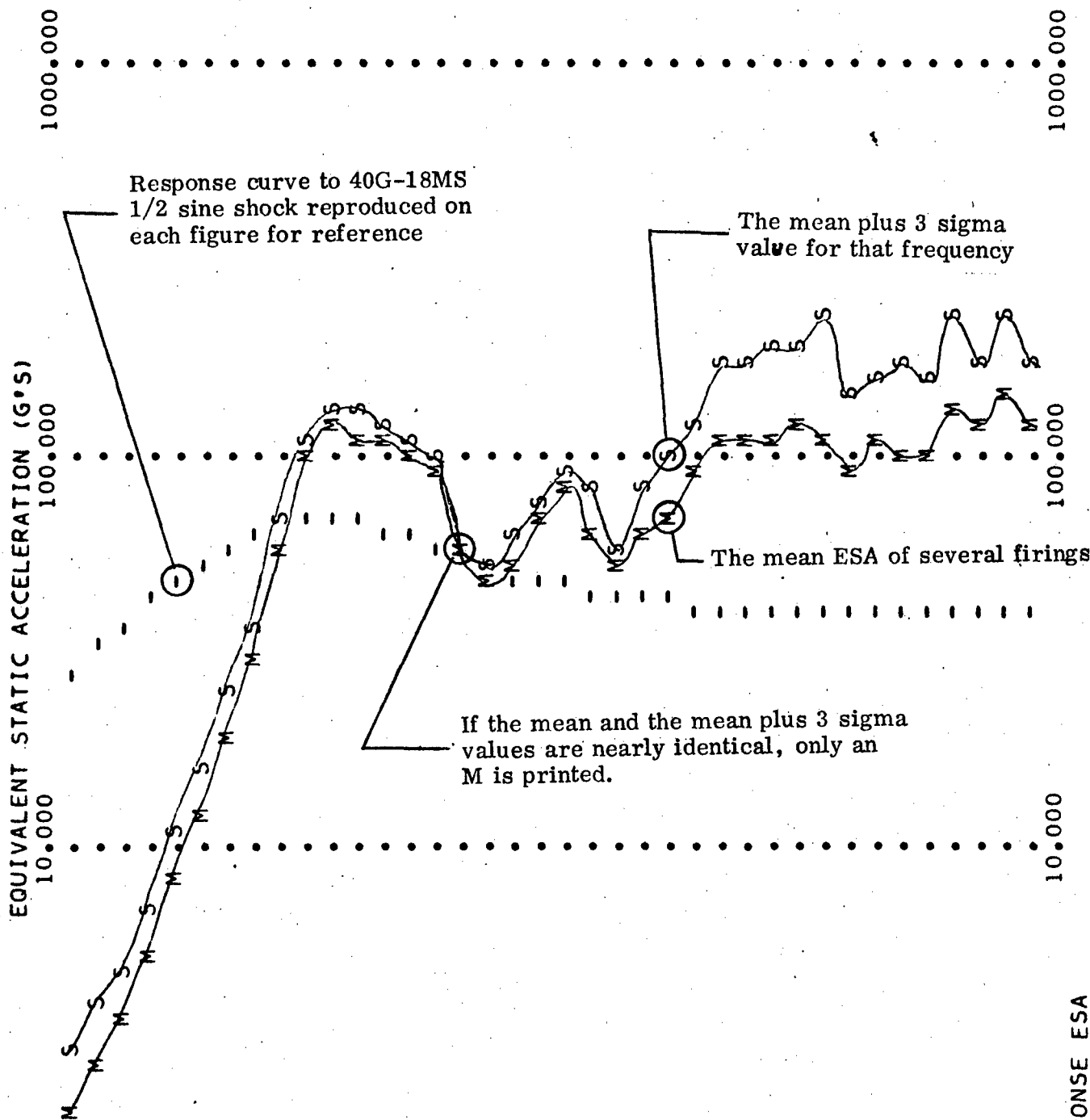
APPENDIX A

GUN FIRING SHOCK SPECTRA E. S. A. 's

FREQ
HZ 1.000
10.000.
11.659.
13.594.
15.849.
18.478.
21.544.
25.119.
29.286.
34.145.
39.811.
46.416.
54.117.
63.096.
73.564.
85.770.
100.000.
116.591.
135.936.
158.489.
184.785.
215.443.
251.189.
292.864.
341.455.
398.107.
464.159.
541.170.
630.957.
735.642.
857.696.
1000.000.
1165.914.
1359.356.
1584.893.
1847.850.
2154.435.
2511.886.
2928.645.
HZ 1.000

Frequency - Hertz

Format of Following Shock Spectra



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

PUN TIME 0 MINS 0.024 SECS. DATE 09/07/77 12.8793

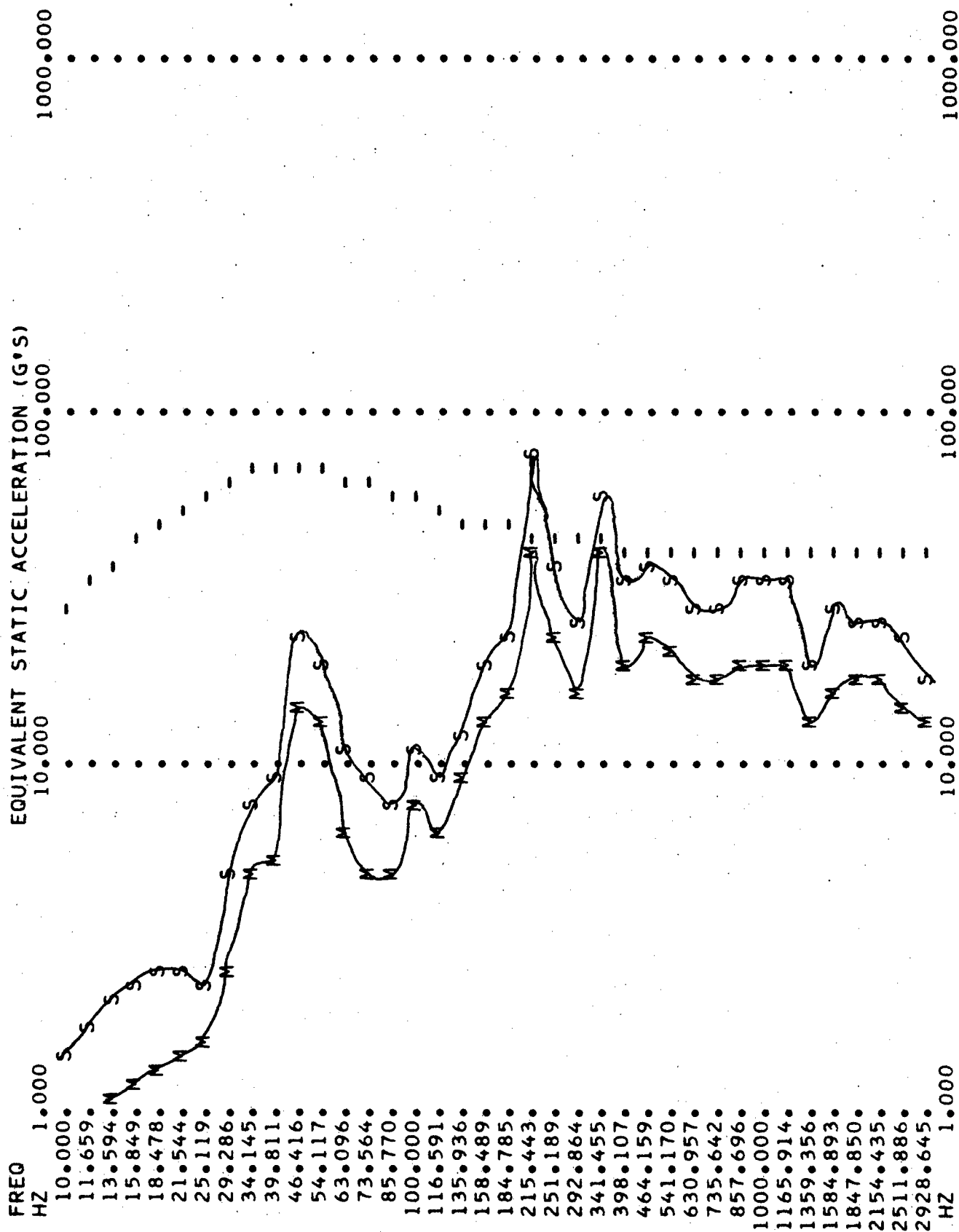
720.00000

55.5555561

AVERAGE 9 PTS. SET 1

JULY 77 TTS GUN SHOCKS TTS PERISCOPE BASE

TRAN



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

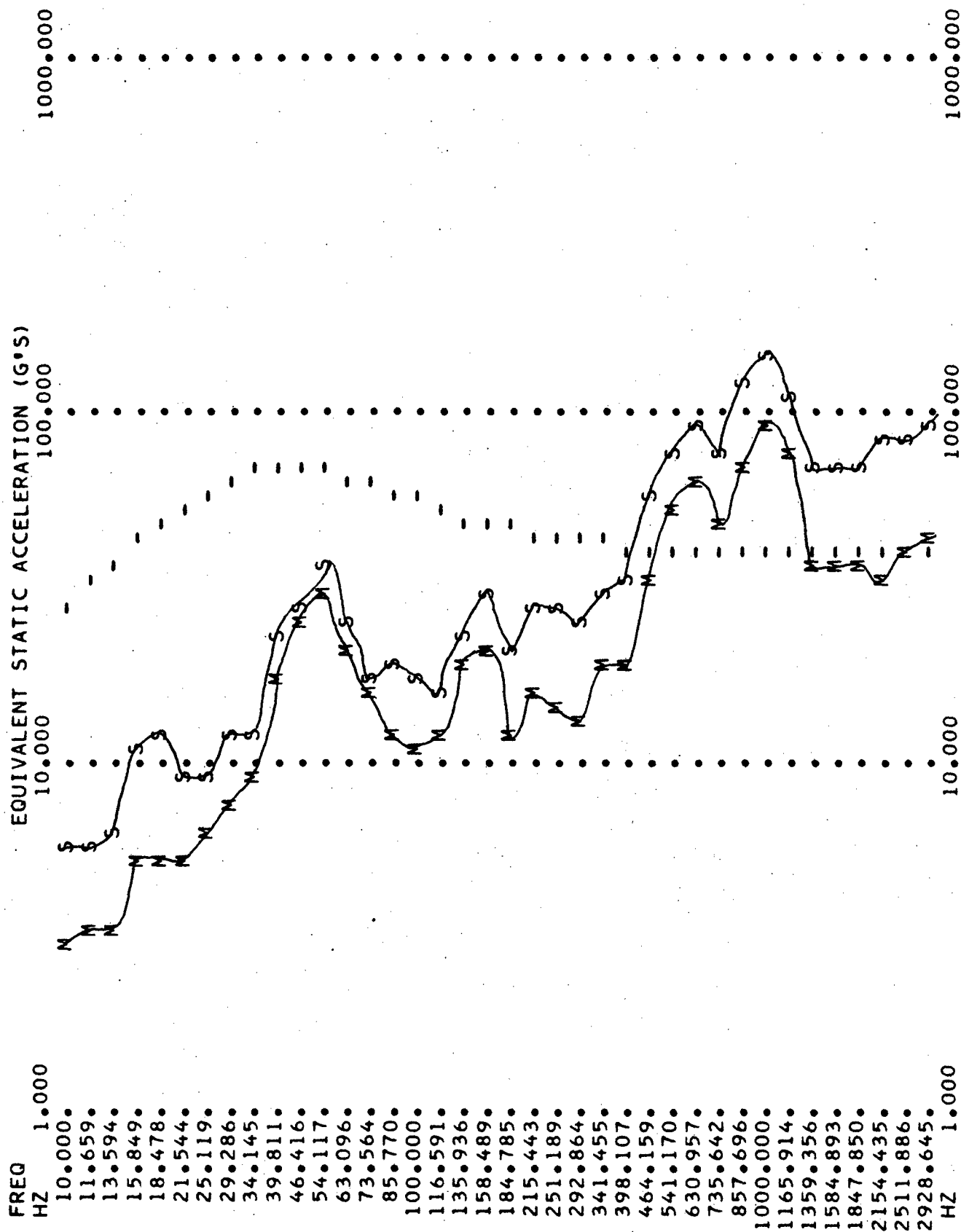
55.55556H

RUN TIME	0 MINS	0.156 SECS.	DATE 09/07/77	12.8793
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AVERAGE 26 PTS, SET 1

JULY 77 TTS GUN SHOCKS TTS PERISCOPE HEAD

LONG



55.5555H

720.00000

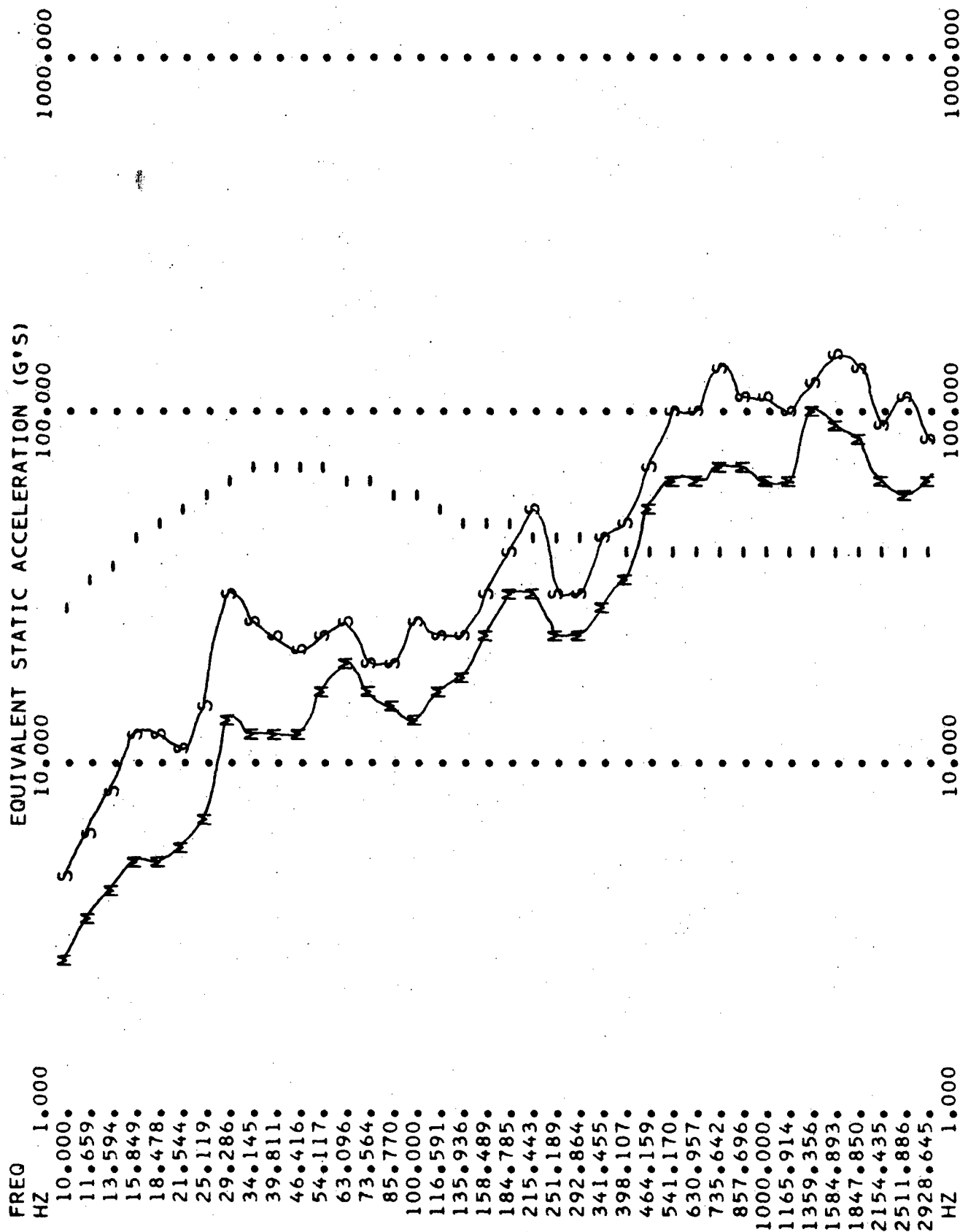
40.00000 G, AT 18.00000 MSEC, SEVERITY=

RUN TIME 0 MINS 0.030 SECS. DATE 09/07/77 12.8793

AVERAGE 9 PTS, SET 1

JULY 77 TTS GUN SHOCKS TTS PERISCOPE HEAD

VERT



M SHOCK RESPONSE ESA

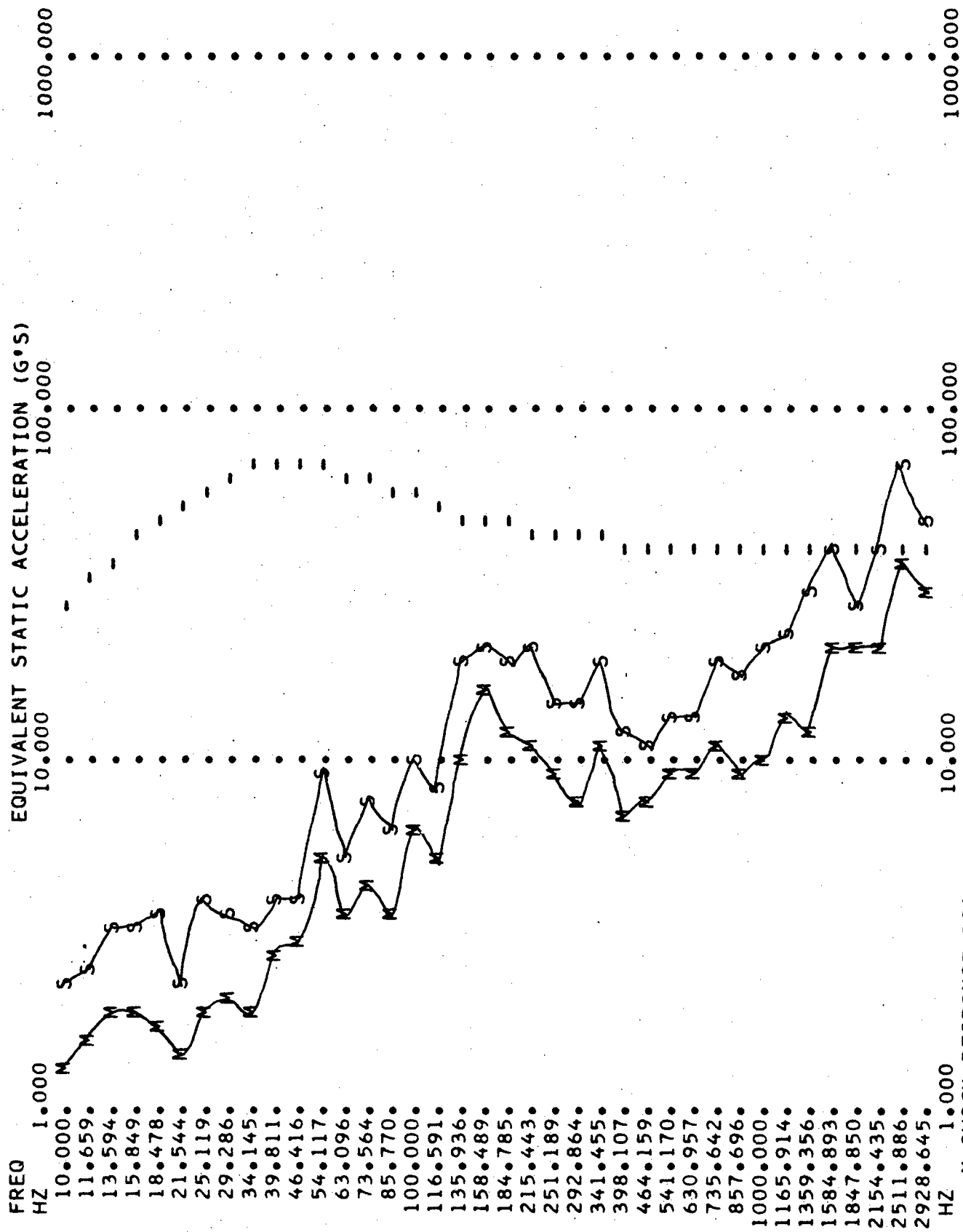
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.555556H;



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

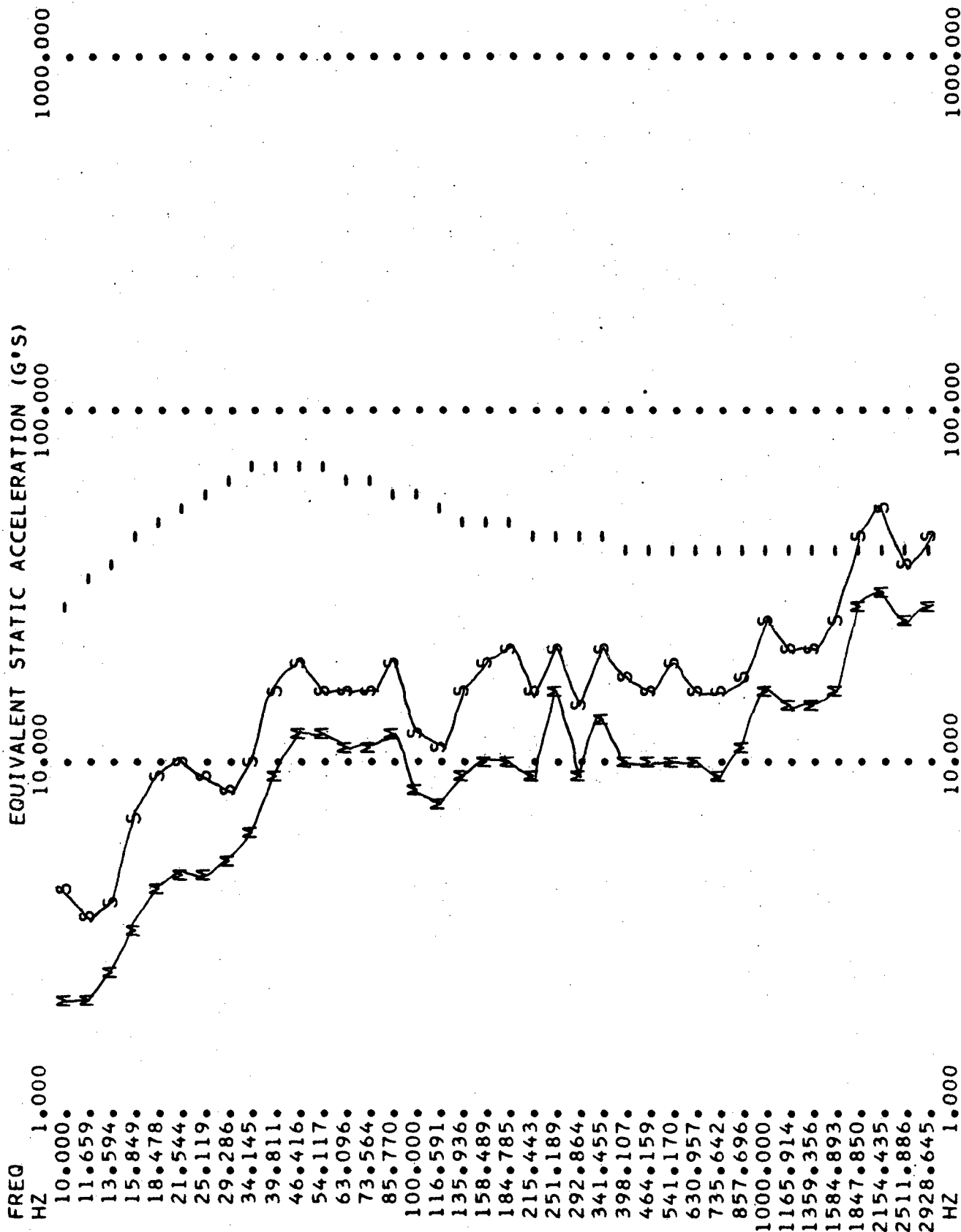
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RUN TIME 0 MINS 0.025 SECS. DATE 09/07/77 12.8793

AVERAGE 38 PTS. SET 1

JULY 77 TTS GUN SHOCKS TURRET ROOF-PERISCOPE INPUT

LONG



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE.

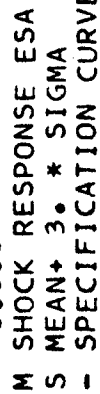
40.00000 G. AT 18.00000 MSEC, SEVERITY=

720.00000

55.555556H.

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VERT



- SPECIFICATION CURVE.

40.00000 G, AT 18.00000 MSEC, SEVERITY=

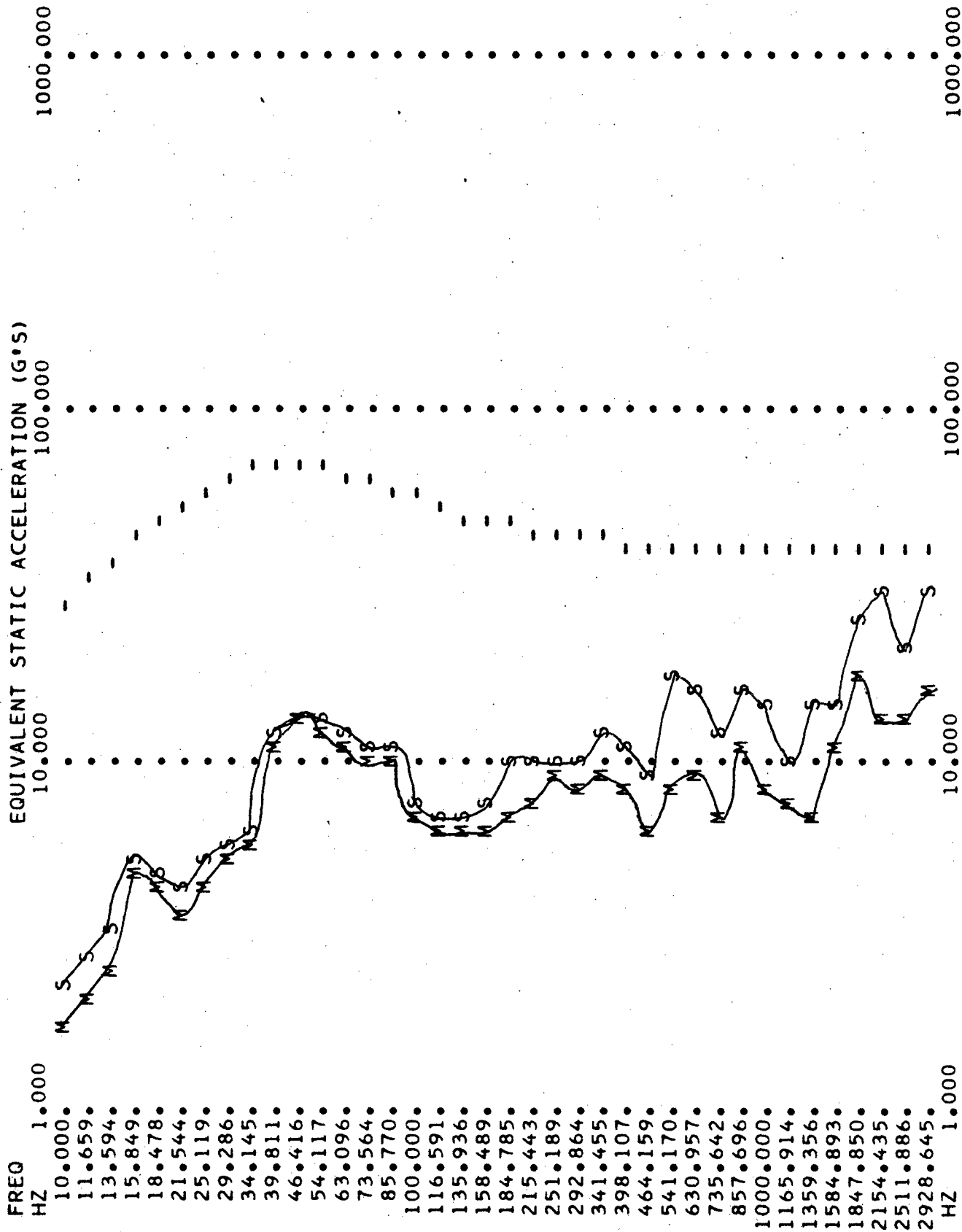
720.00000

55.55556H?

RUN TIME 0 MINS 0.024 SECS. DATE 09/07/77

12.8793

AVERAGE 7 PTS, SET 1 JULY77 TTS GUN SHOCKS TURRET RIGHT WALL(LIGHT ELBOW INPUT) LONG



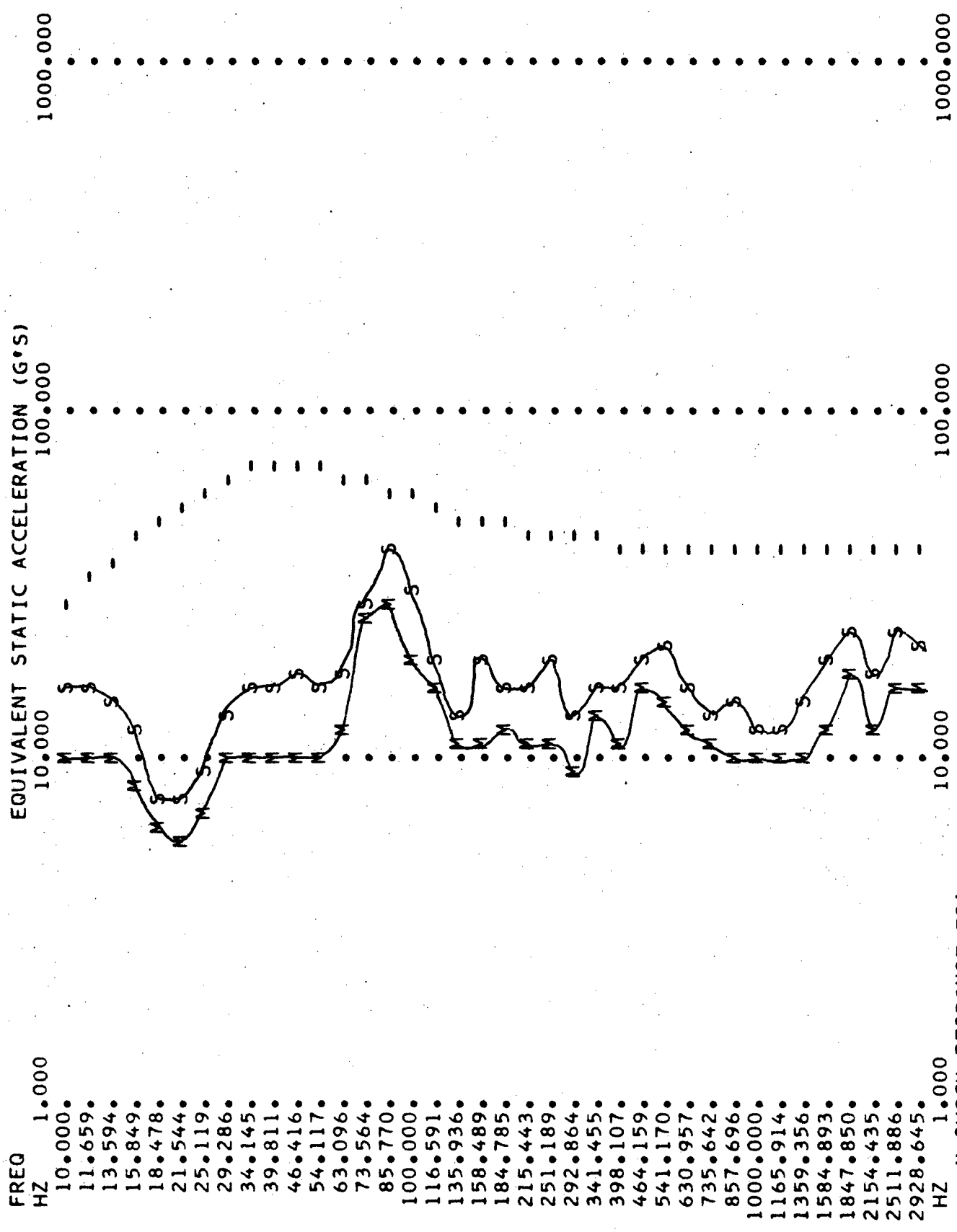
M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.55556H

RUN TIME 0 MINS 0.024 SECS. DATE 09/07/77 12.8793

AVERAGE 6 PTS, SET 1

JULY77 TTS GUN SHOCKS TURRET RIGHT WALL(LIGHT ELBOW INPUT) VERT



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H

TRAN

TTS FLANGE

JULY77 TTS GUN SHOCKS

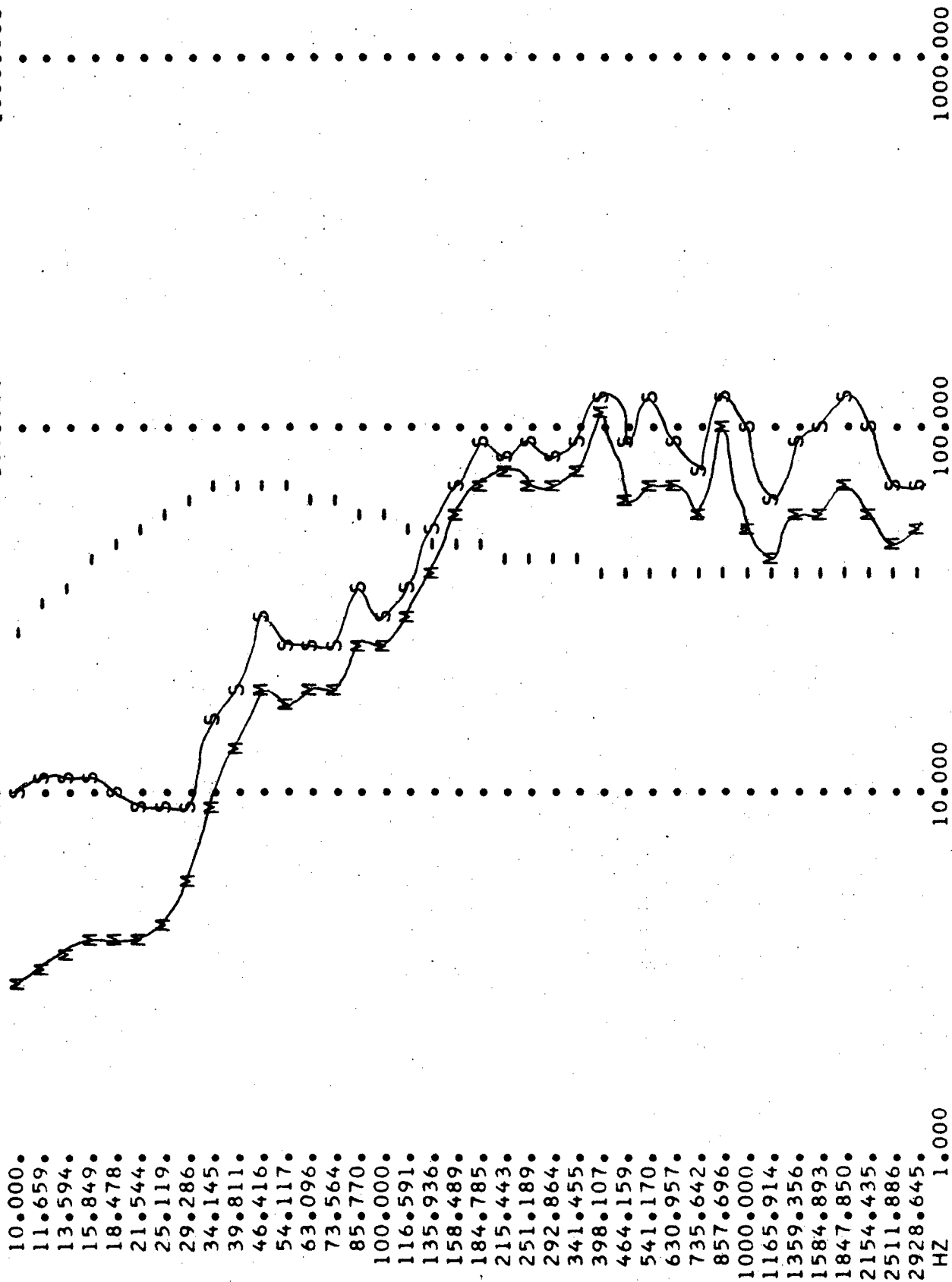
AVERAGE 7 PTS, SET 1

FREQ

HZ 1.000

EQUIVALENT STATIC ACCELERATION (G'S)

10.000 100.000 1000.000



HZ 1.000

10.000 100.000 1000.000

M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

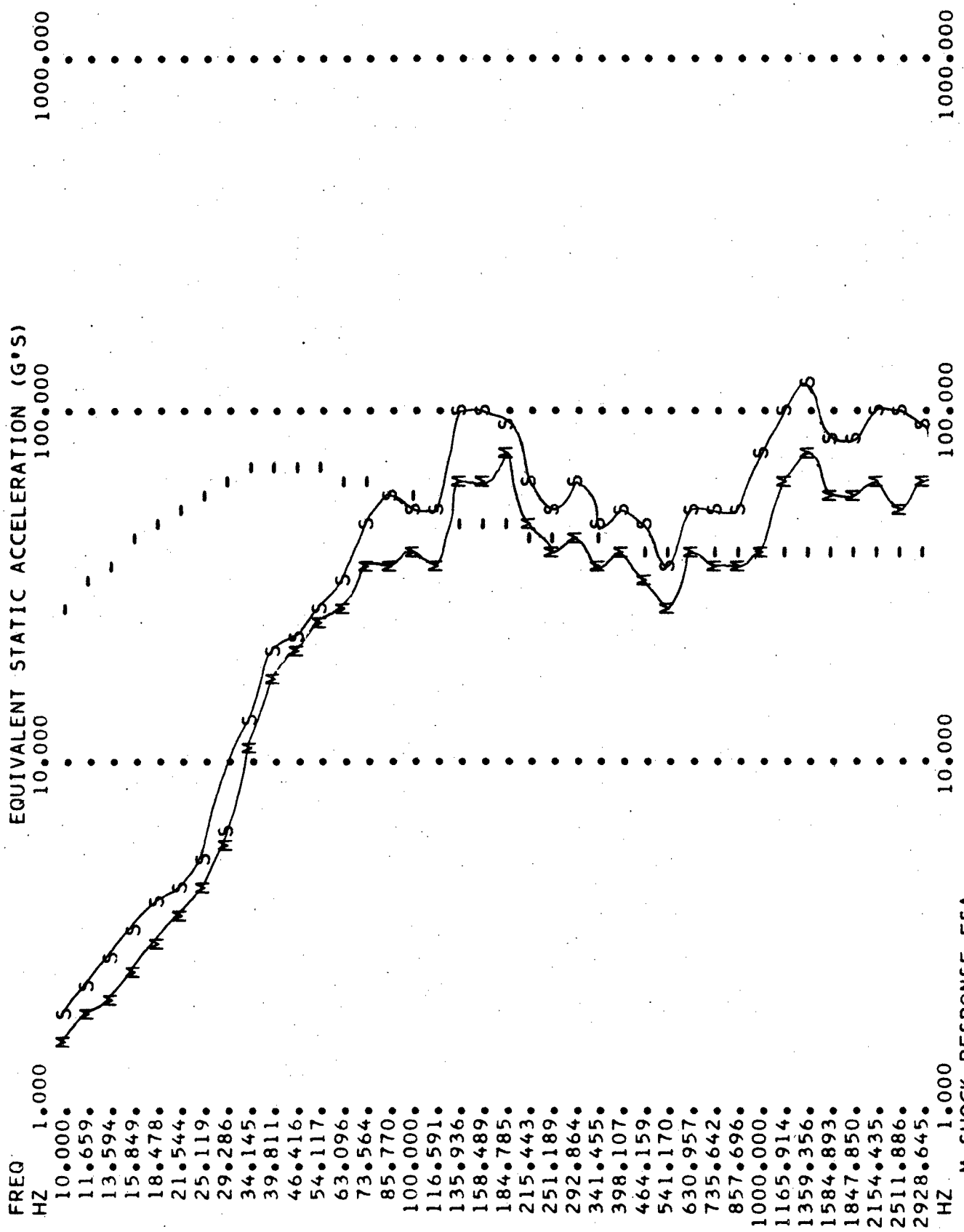
- SPECIFICATION CURVE,

40.00000 G, AT-18.00000 MSEC, SEVERITY=

720.00000

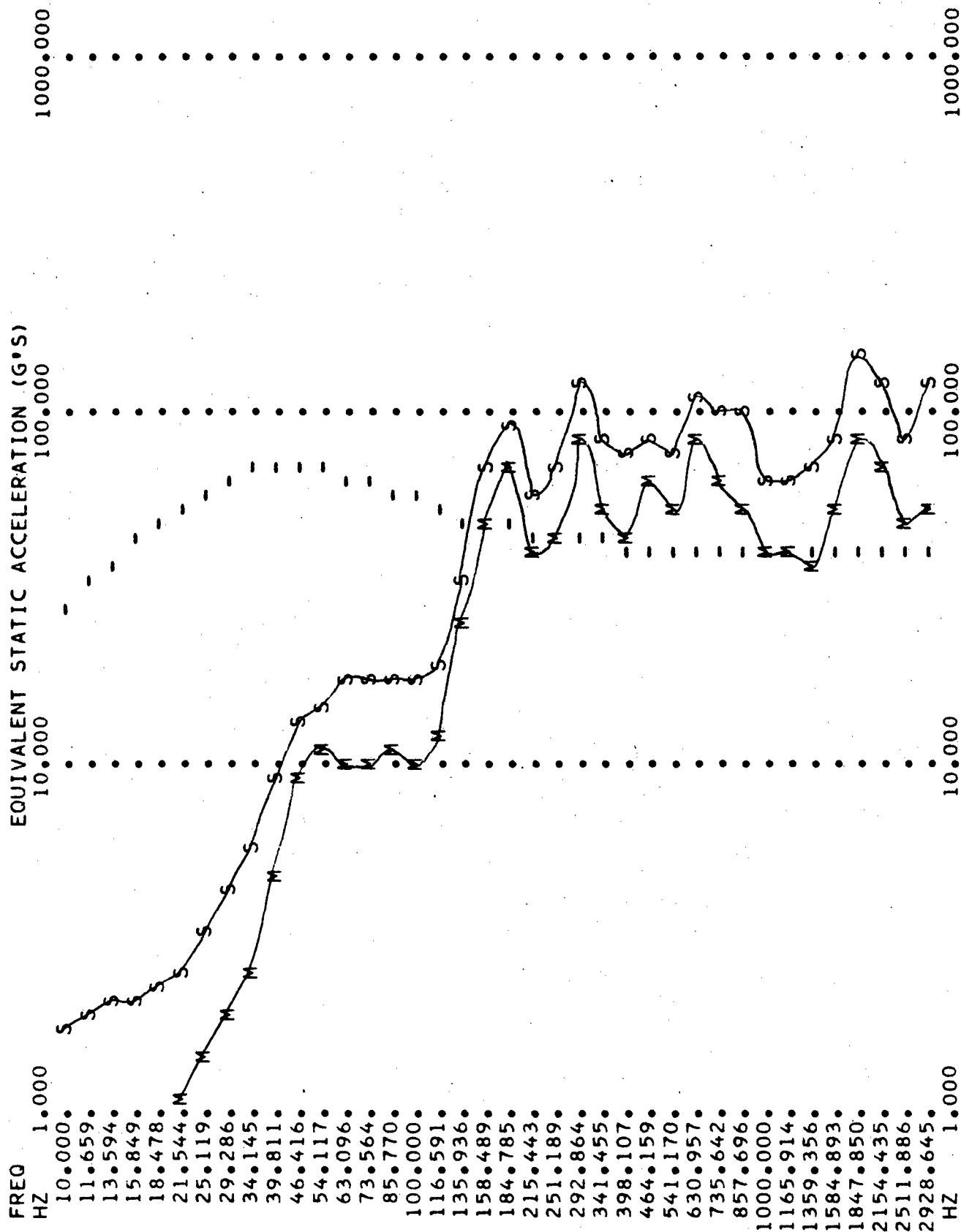
55.55556HZ

RUN TIME 0 MINS 0.023 SECS, DATE 09/07/77 12.8793



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

VERT



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

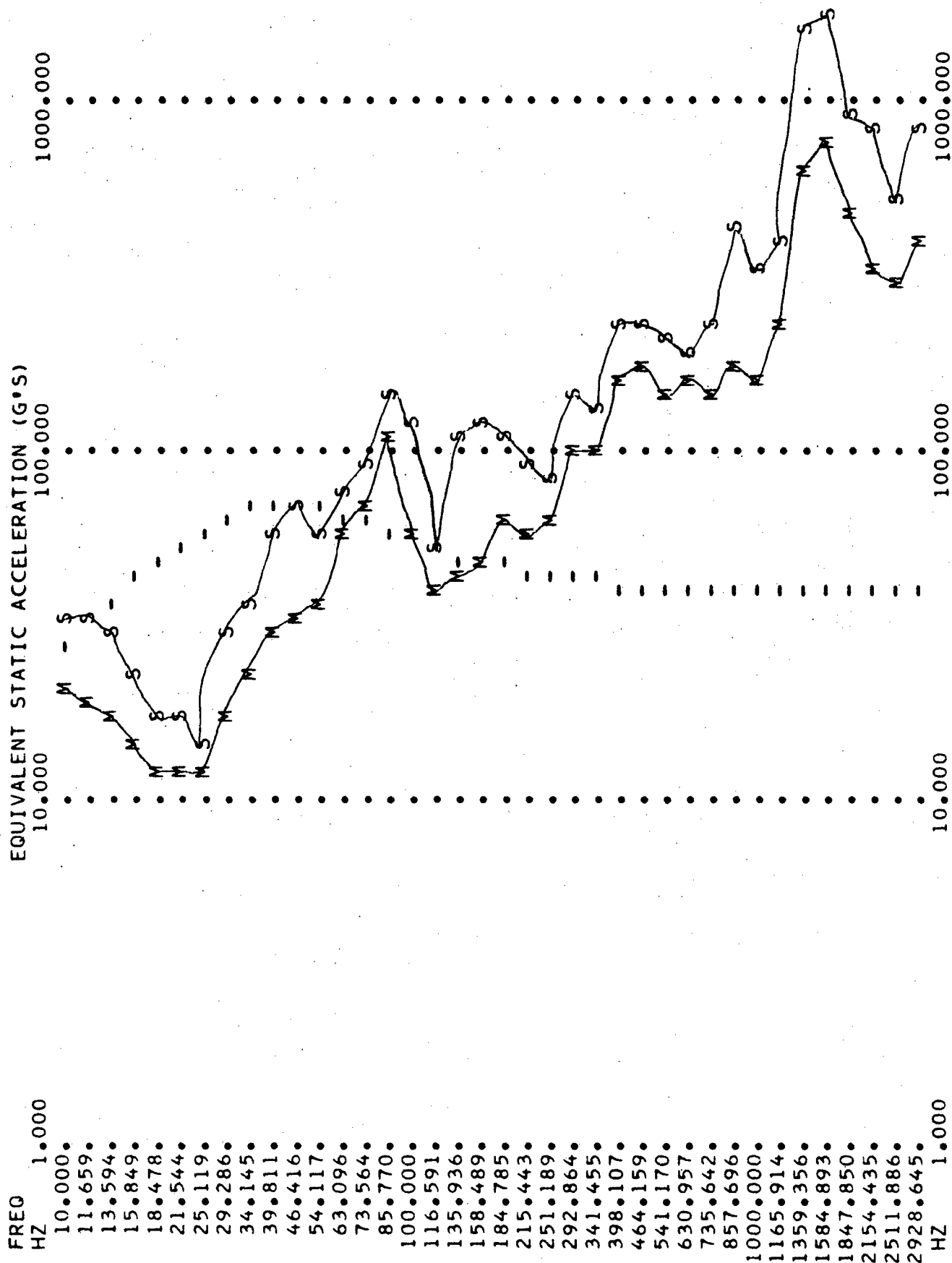
720.000000

55.55556HZ

RUN TIME 0 MINS 0.024 SECS. DATE 09/07/77

12.8793

AVERAGE 5 PTS, SET 1 JULY77 TTS GUN SHOCKS NO-BAK HOUSING (LIGHT ELBOW INPUT) VERT



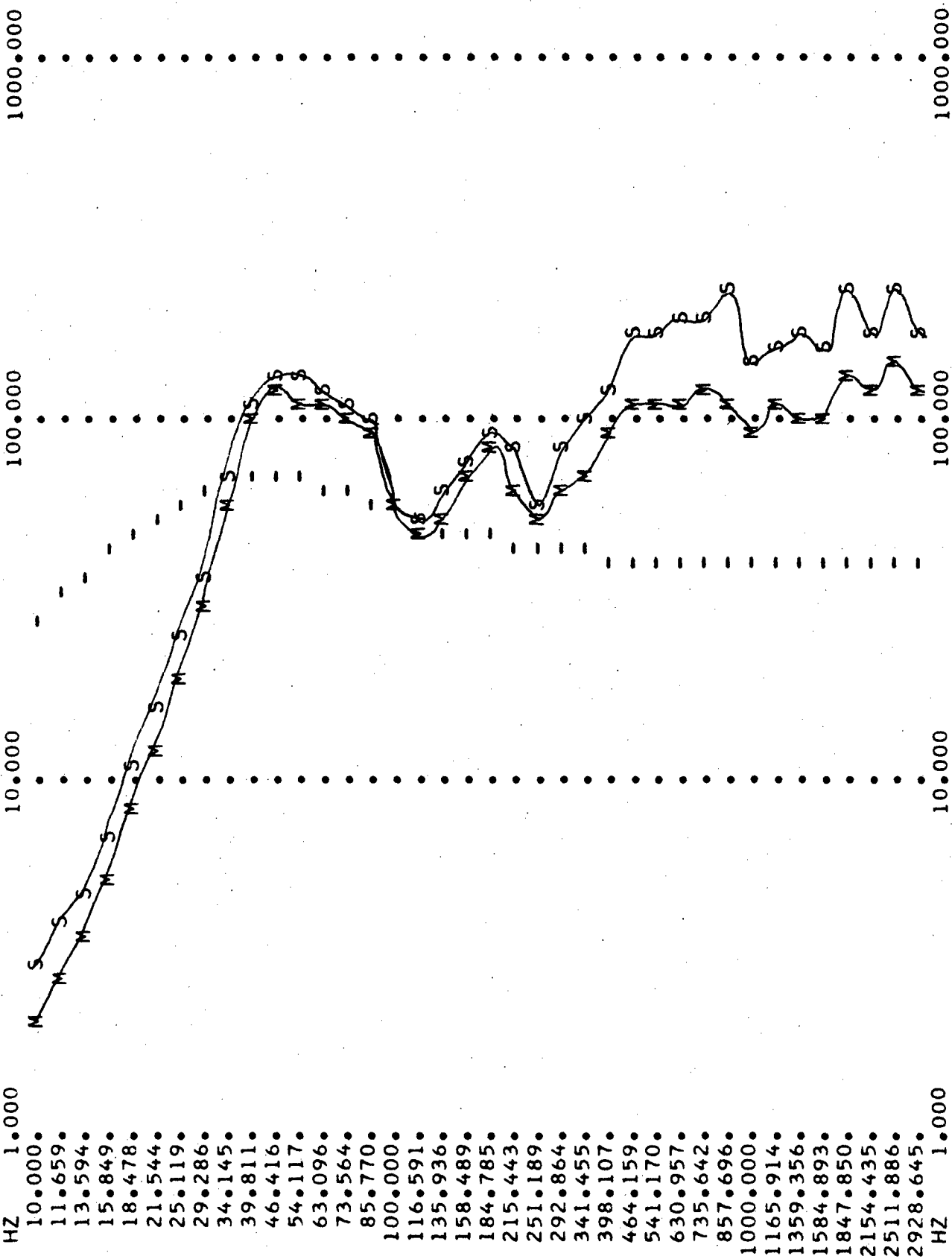
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RUN TIME 0 MINS 0.023 SECS. DATE 09/07/77 12.8793

AVERAGE

TRAN

FREQ

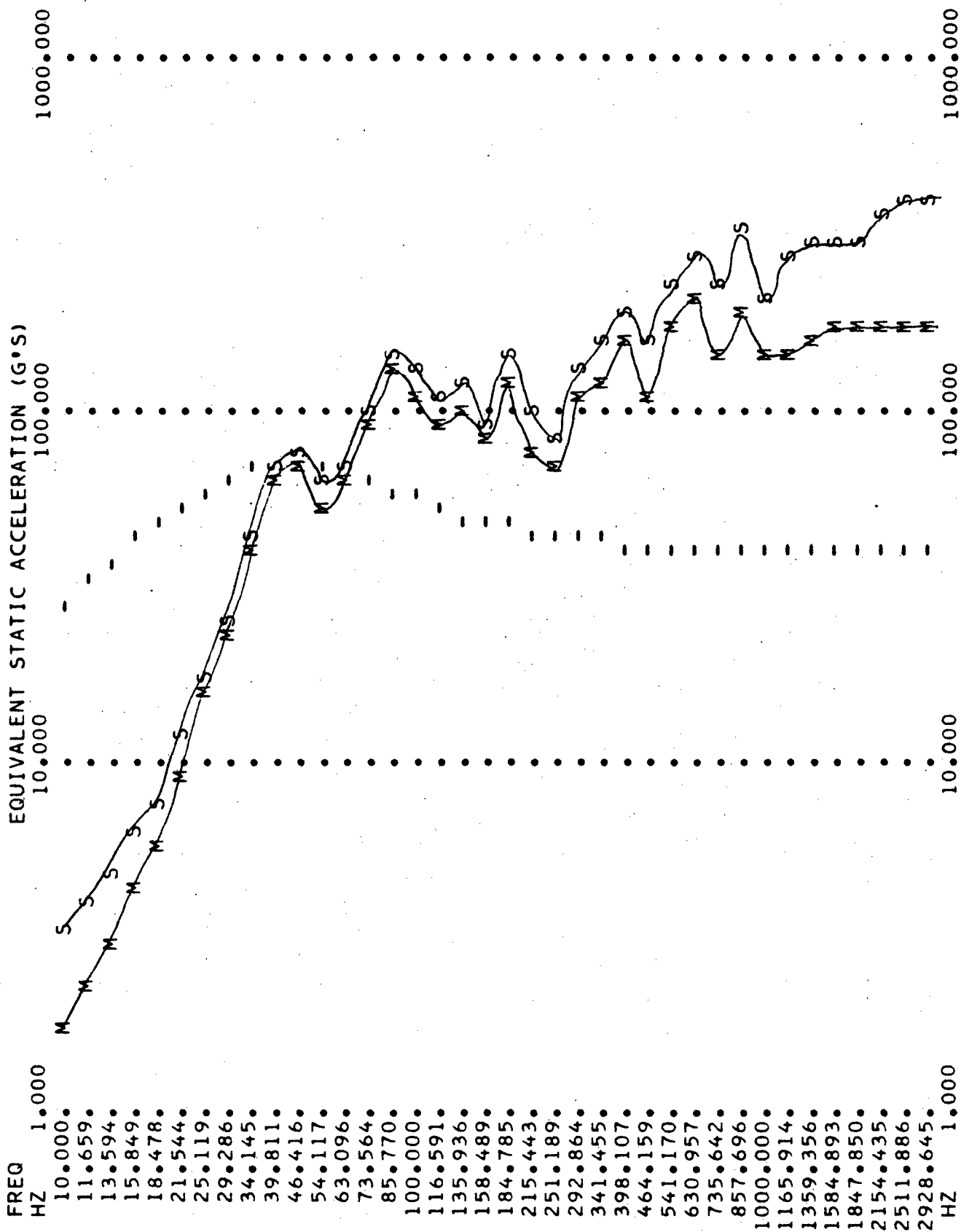


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55.55556HZ

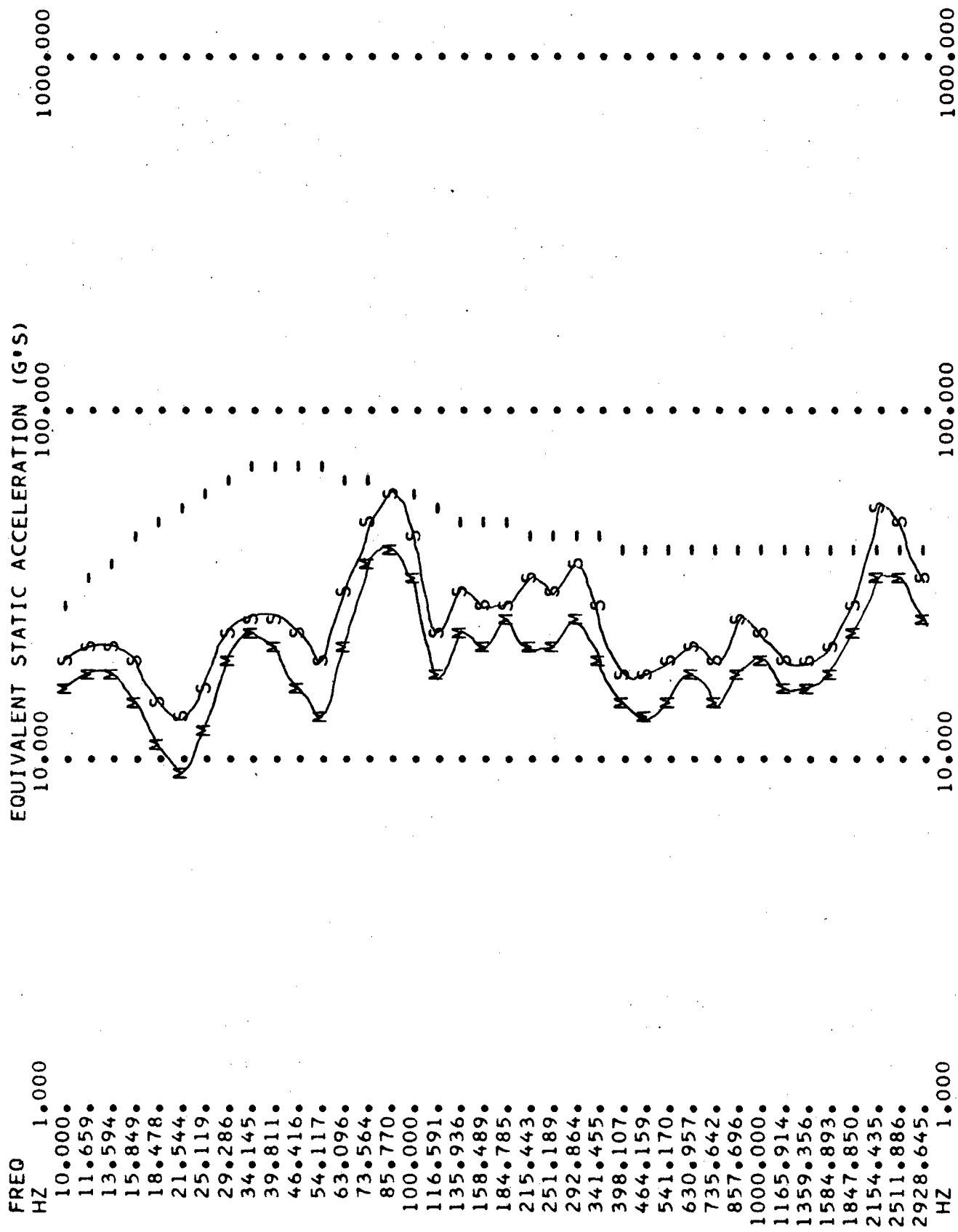
COMM TIME	N MINC	N NCL	SFCS	DATE	NO/N7/77	
						12.8793

AVERAGE	10 PTS.	SET	JULY77	TTS	GUN	SHOCKS	COMDRS.	VIEWER	VERT
		1							



RUN TIME 0 MINS 0.025 SECS. DATE 09/07/77 12.8793

AVERAGE 9 PTS, SET 1 JULY77 TTS GUN SHOCKS TURRET BUSTLE ROOF (PWR, CONV, INPUT) TRAN



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

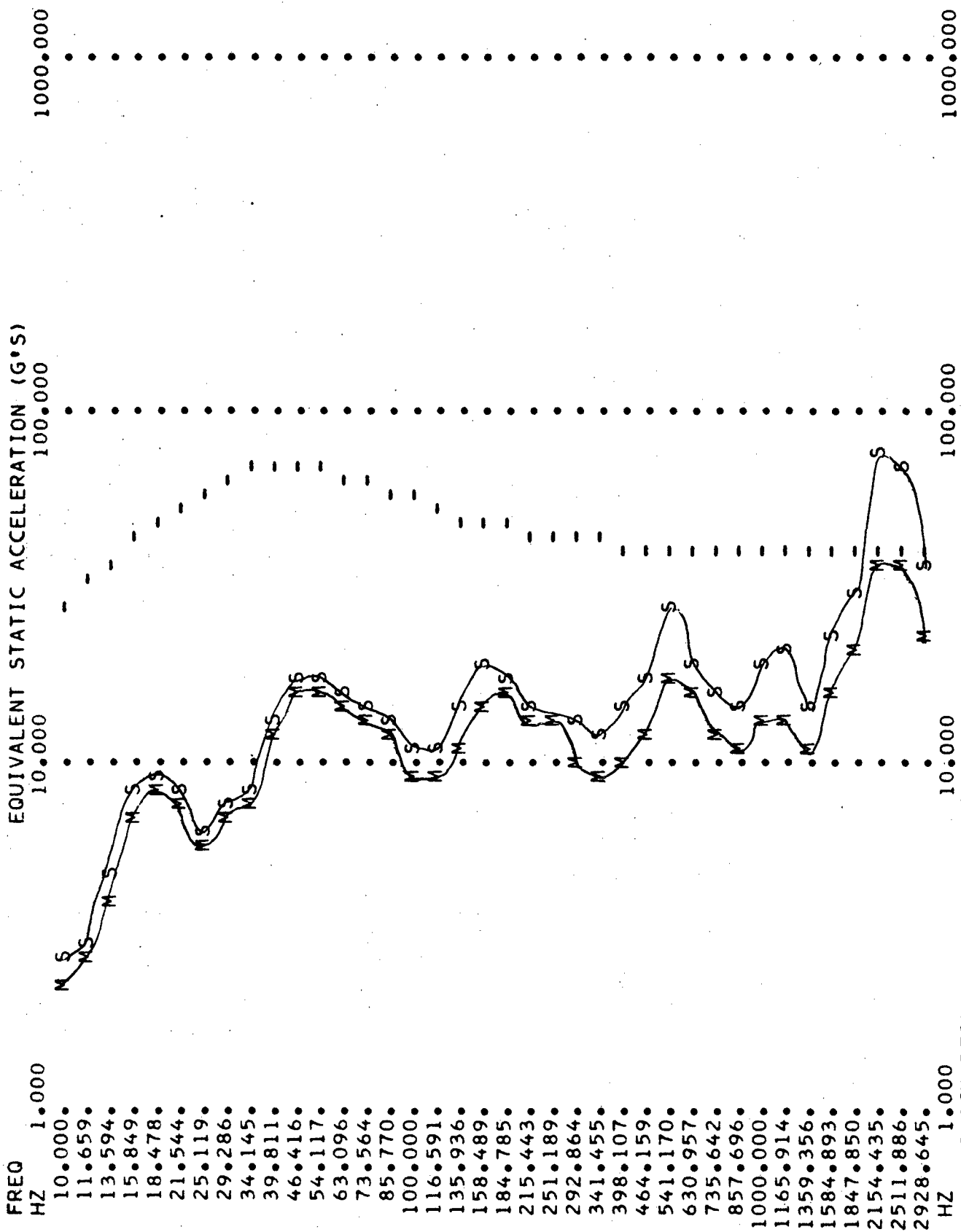
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40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H;

RIN TIME	0 MINS	0-024 SFCS.	DATE 09/07/77	12.8793
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M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

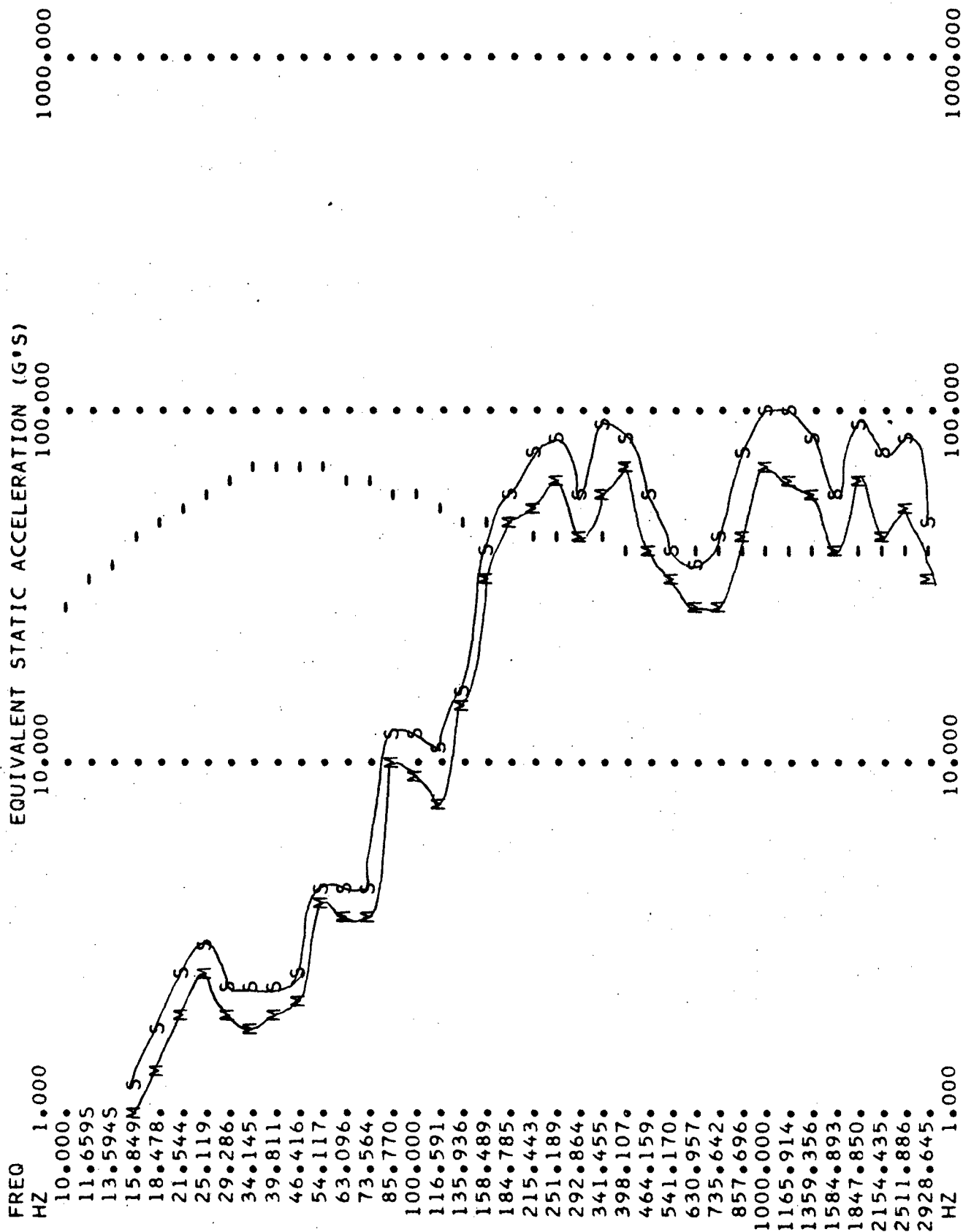
720.00000

55.555556H.

AVERAGE 9 PTS, SET 1

JULY77 TTS GUN SHOCKS POWER CONVERTER HOUSING

TRAN



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

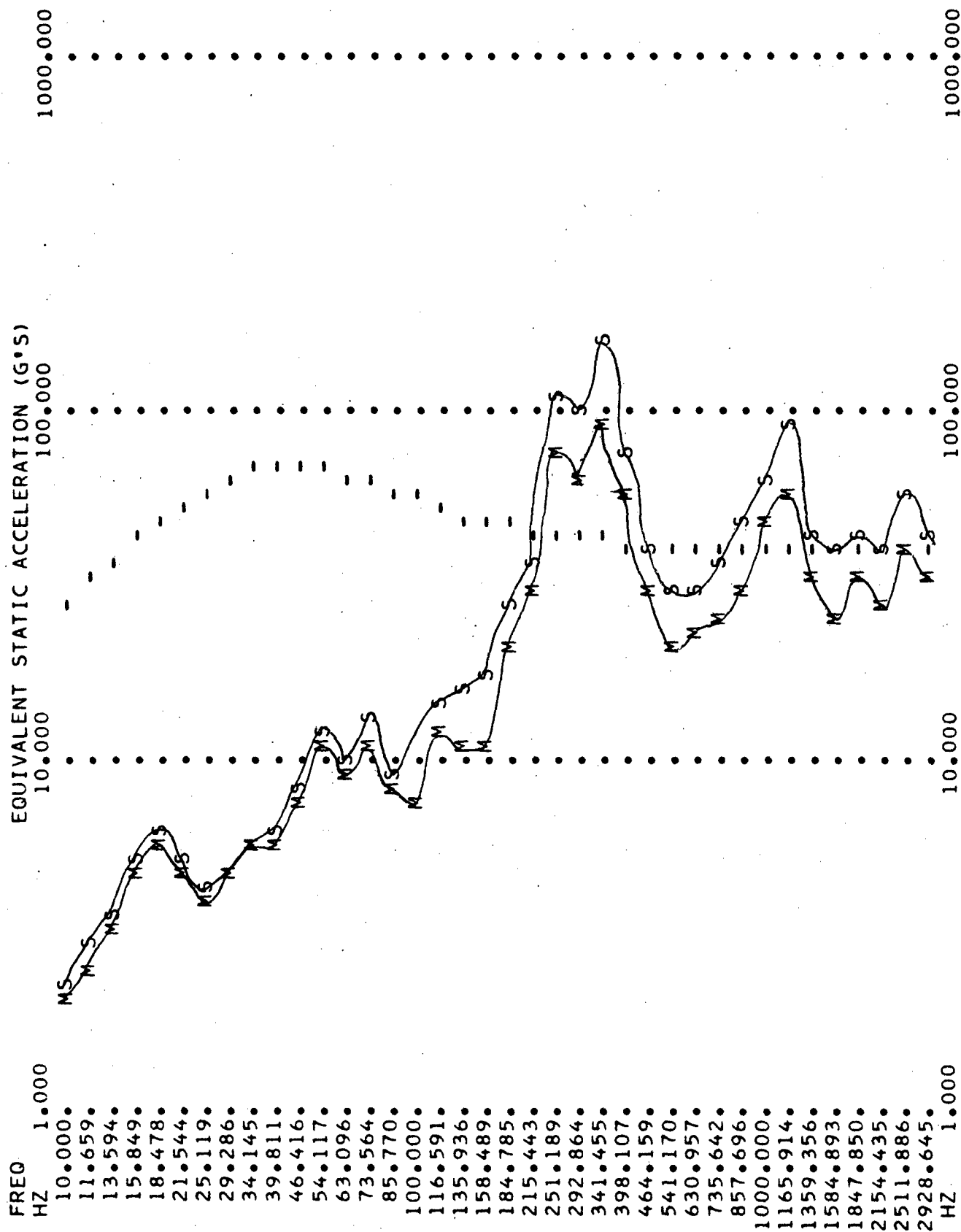
- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H

LONG



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

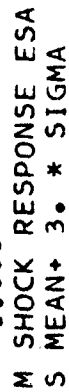
- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.5556H

RUN TIME 0 MINS 0.024 SECS. DATE 09/07/77	12.8793
--	---------

VERT



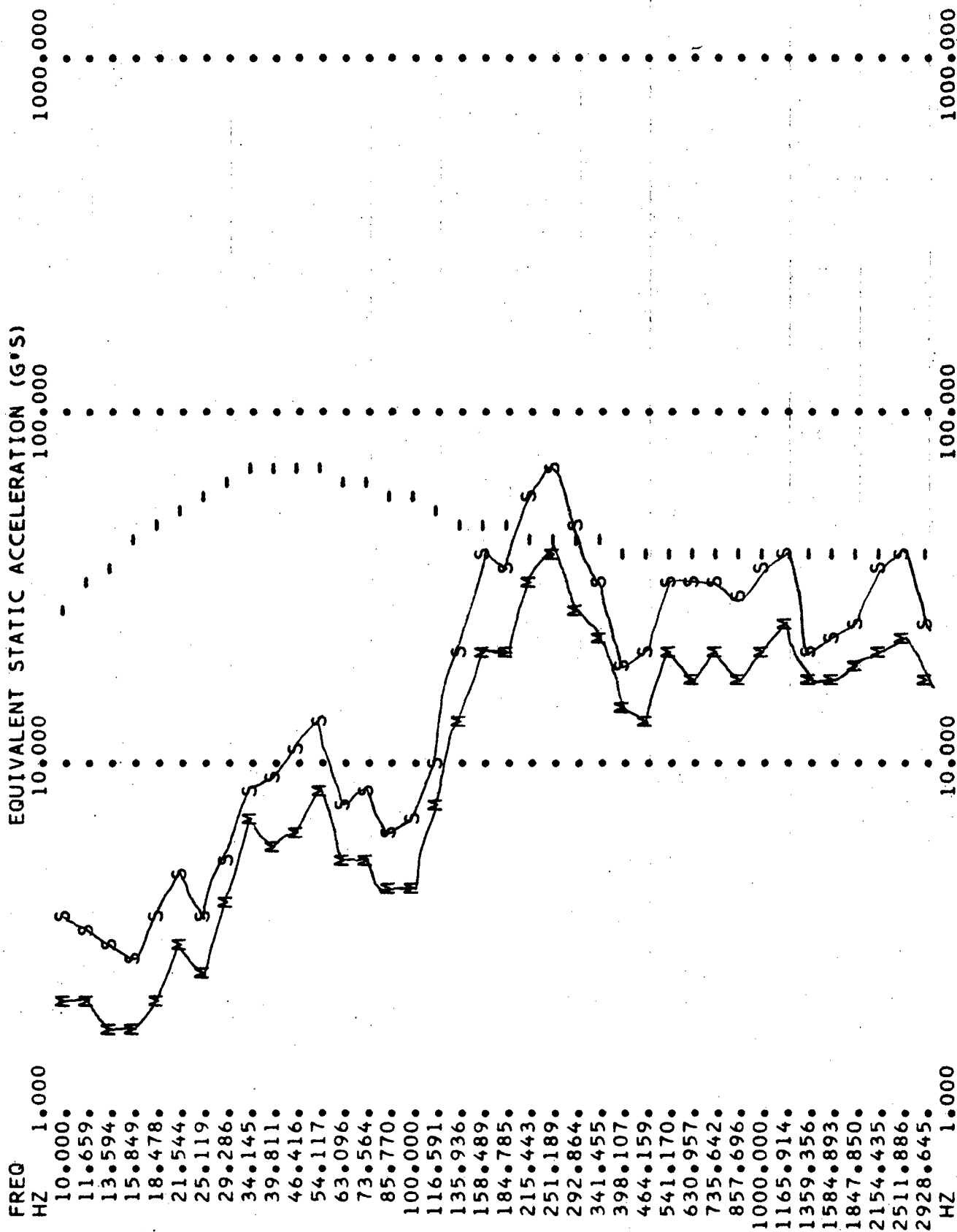
55.5555H

DATE	TIME	MIN	SEC	DATE	TIME
09/07/77	12.8793			09/07/77	12.8793

TRAN

JULY 77 TTS GUN SHOCKS TTS PERISCOPE BASE

AVERAGE 8 PTS, SET 1



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.090 SECS. DATE 09/01/77 9.6617

LONG

JULY 77 TTS GUN SHOCKS TTS PERISCOPE BASE

AVERAGE 8 PTS, SET 1

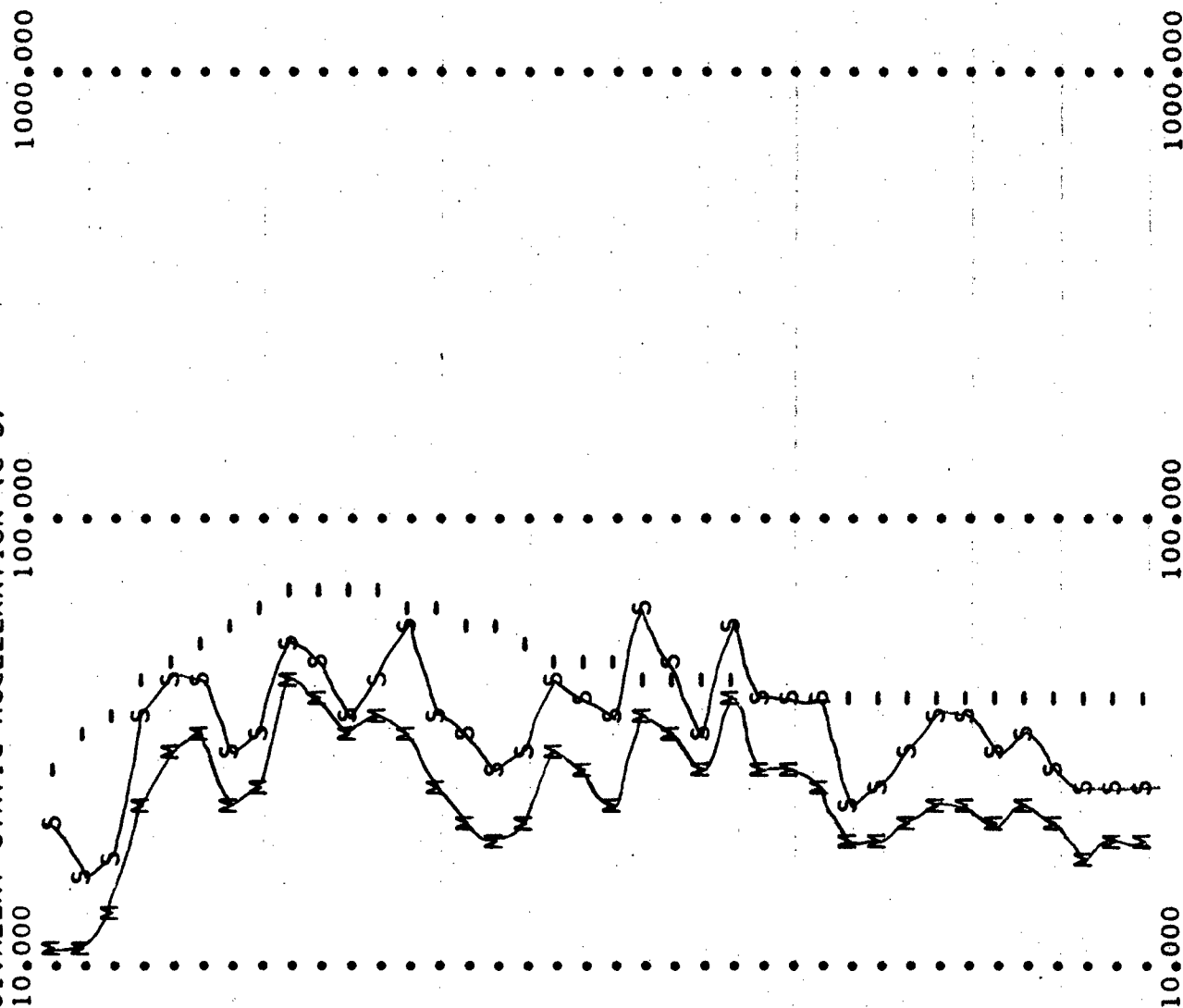
EQUIVALENT STATIC ACCELERATION (G'S)

FREQ
HZ 1,000

10,000.
11,659.
13,594.
15,849.
18,478.
21,544.
25,119.
29,286.
34,145.
39,811.
46,416.
54,117.
63,096.
73,564.
85,770.
100,000.
116,591.
135,936.
158,489.
184,785.
215,443.
251,189.
292,864.
341,455.
398,107.
464,159.
541,170.
630,957.
735,642.
857,696.
1000,000.
1165,914.
1359,356.
1584,893.
1847,850.
2154,435.
2511,886.
2928,645.

HZ 1,000

M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA
- SPECIFICATION CURVE,



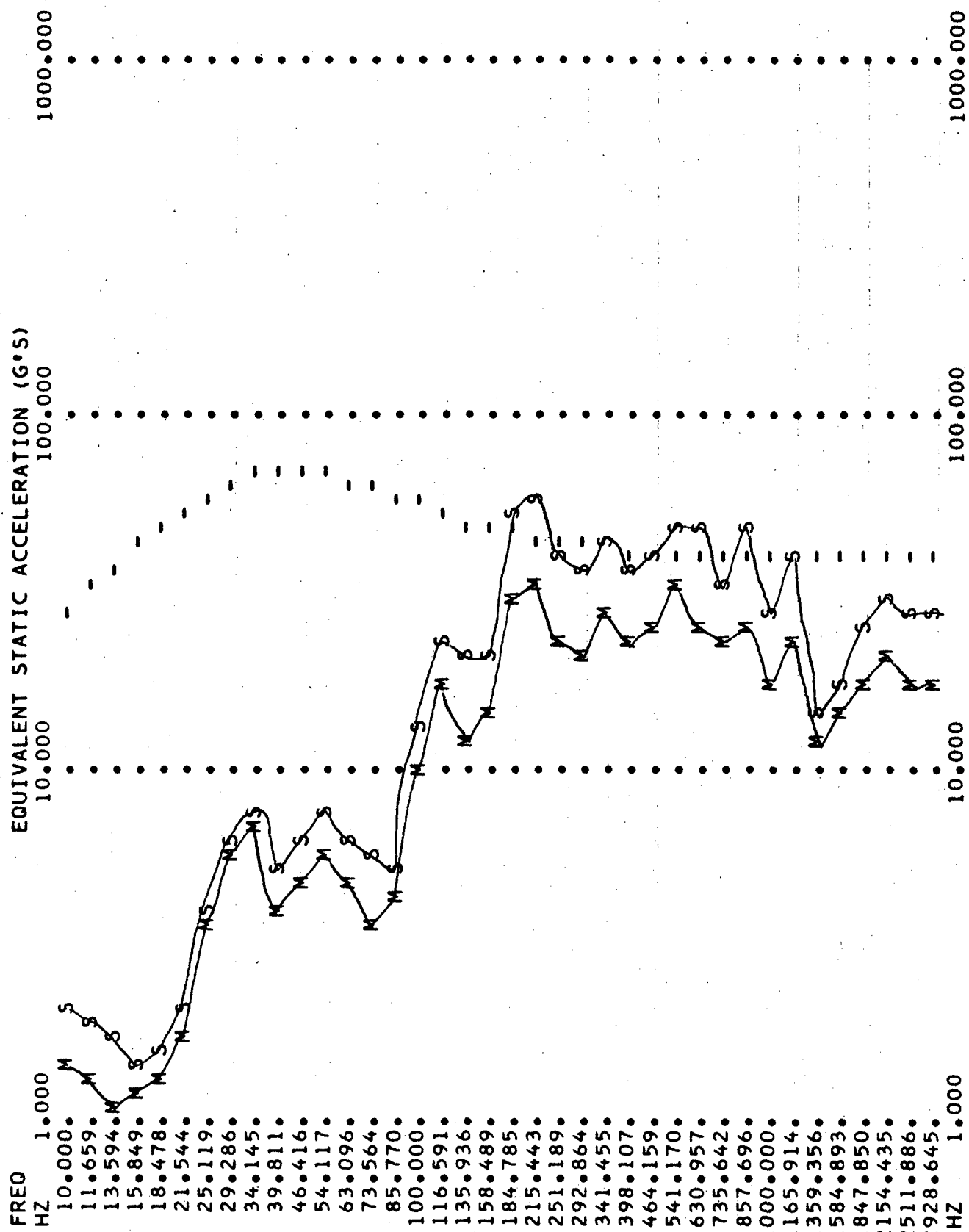
55.55556HZ

720.00000

40.00000 G, AT 18.00000 MSEC, SEVERITY=

RUN TIME 0 MINS 0.023 SECS. DATE 09/01/77 9.6617

VERT



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

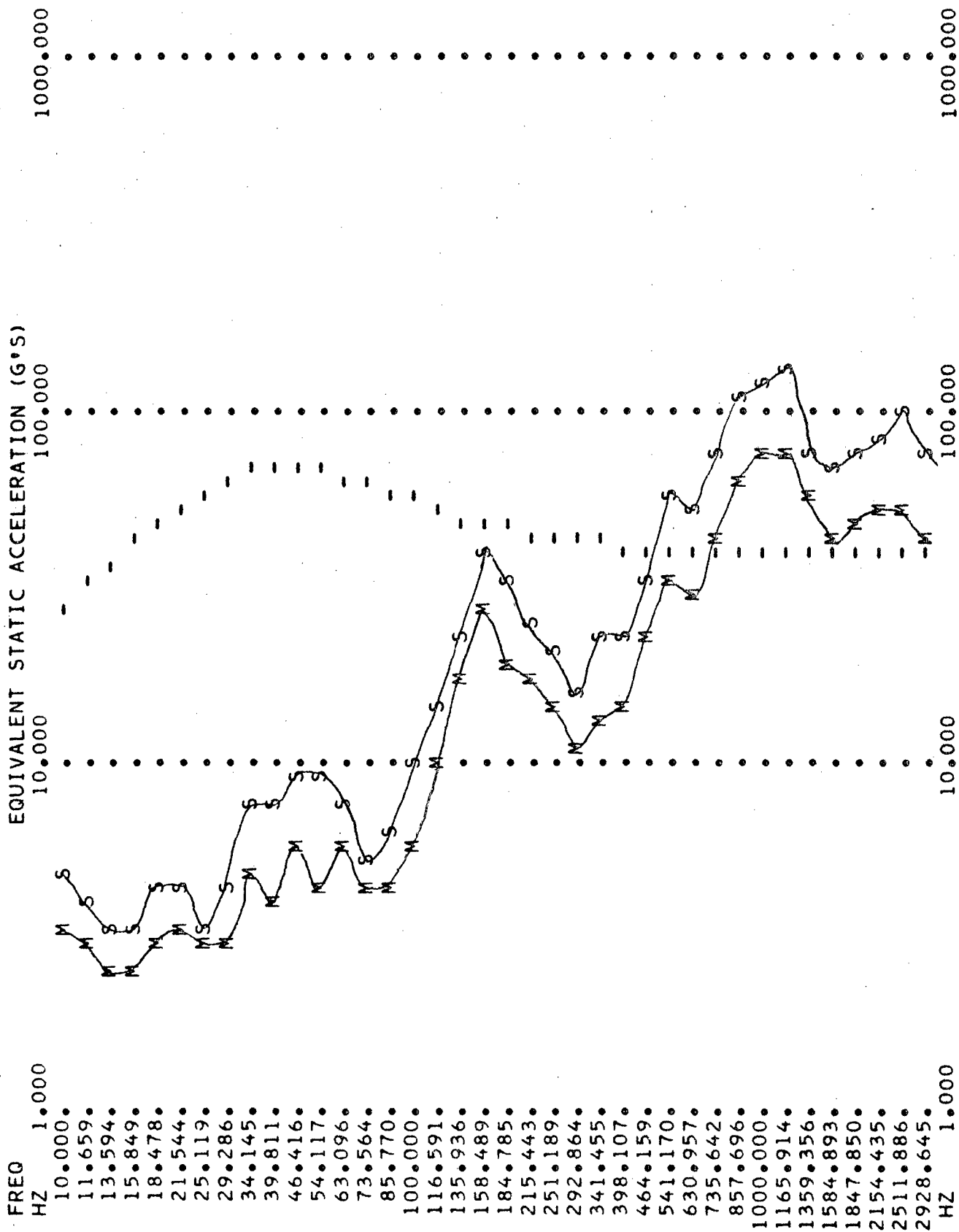
SEVERITY= 720.00000
40.00000 G. AT 18.00000 MSEC, SEVERITY= 720.00000
SPECIFICATION CURVE, 55.55556HZ

RUN TIME 0 MINS 0.023 SECS. DATE 09/01/77 9.6617

AVERAGE 8 PTS, SET 1

JULY 77 TTS GUN SHOCKS TTS PERISCOPE HEAD

TRAN



M SHOCK RESPONSE ESA

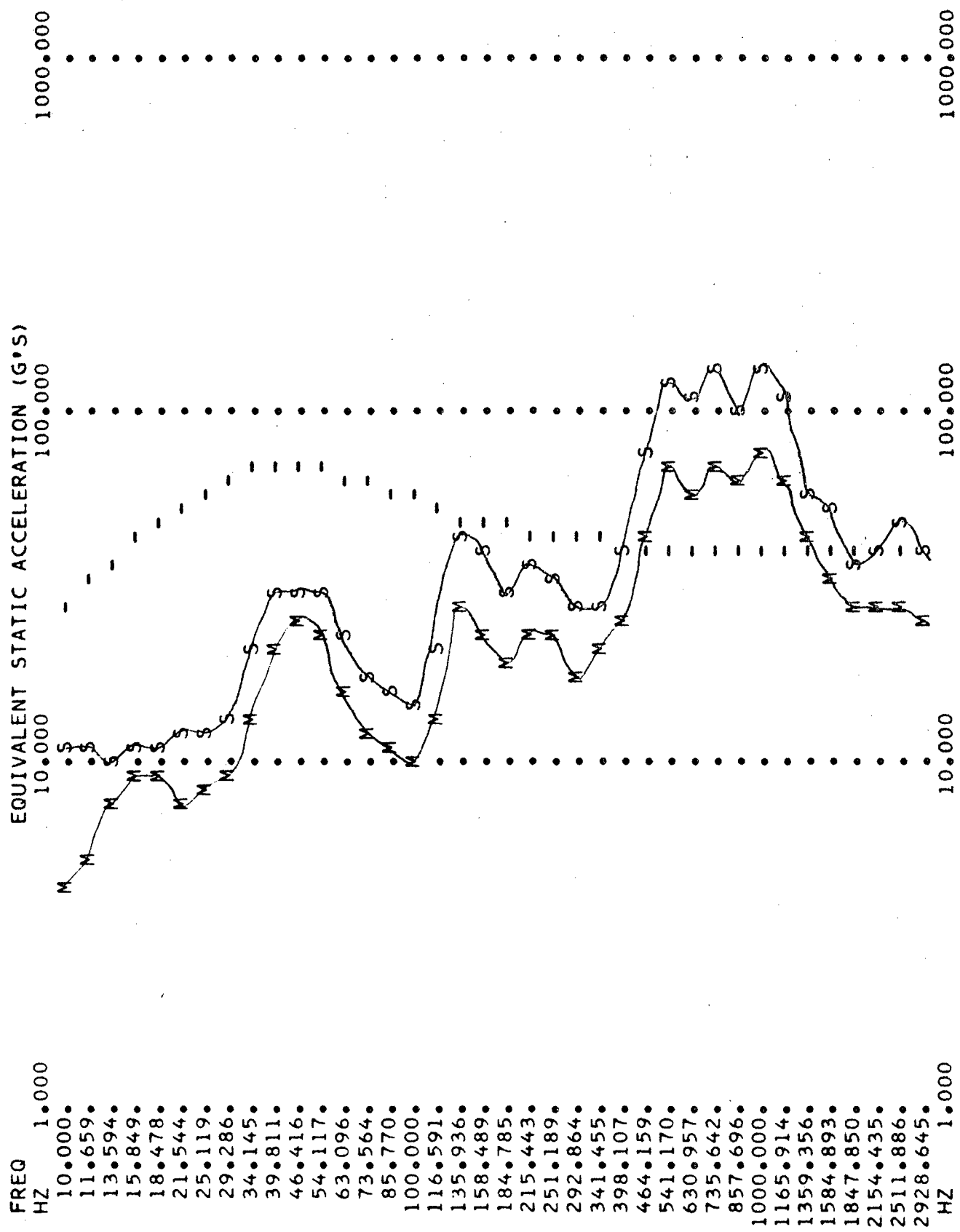
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.023 SECS, DATE 09/01/77 9.6617



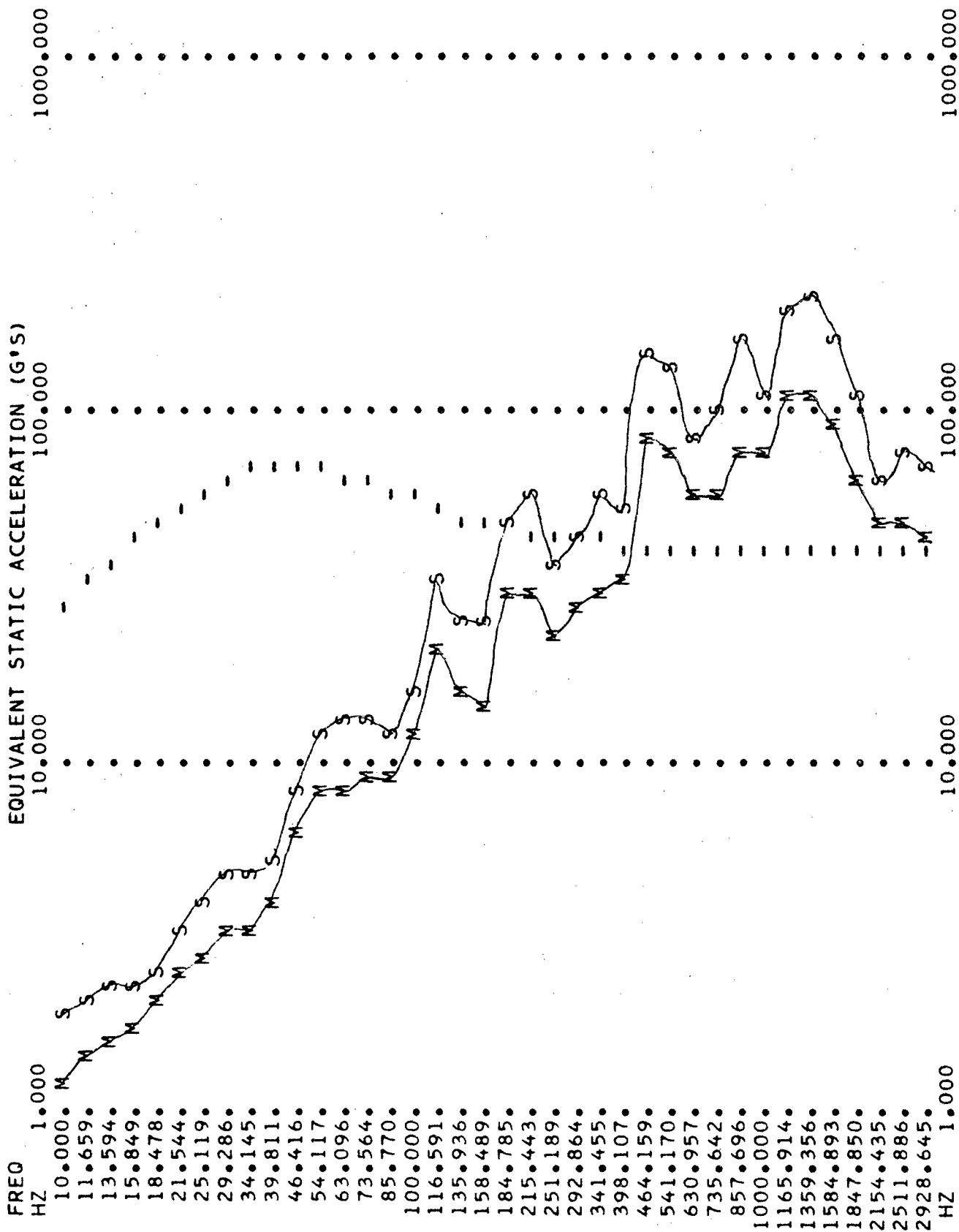
M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA
- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.555556HZ

AVERAGE 8 PTS. SET 1

JULY 77 TTS GUN SHOCKS TTS PERISCOPE HEAD

VERT



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

DIN TIME 0 MINS 0.023 SECS. DATE 09/01/77

9.6617

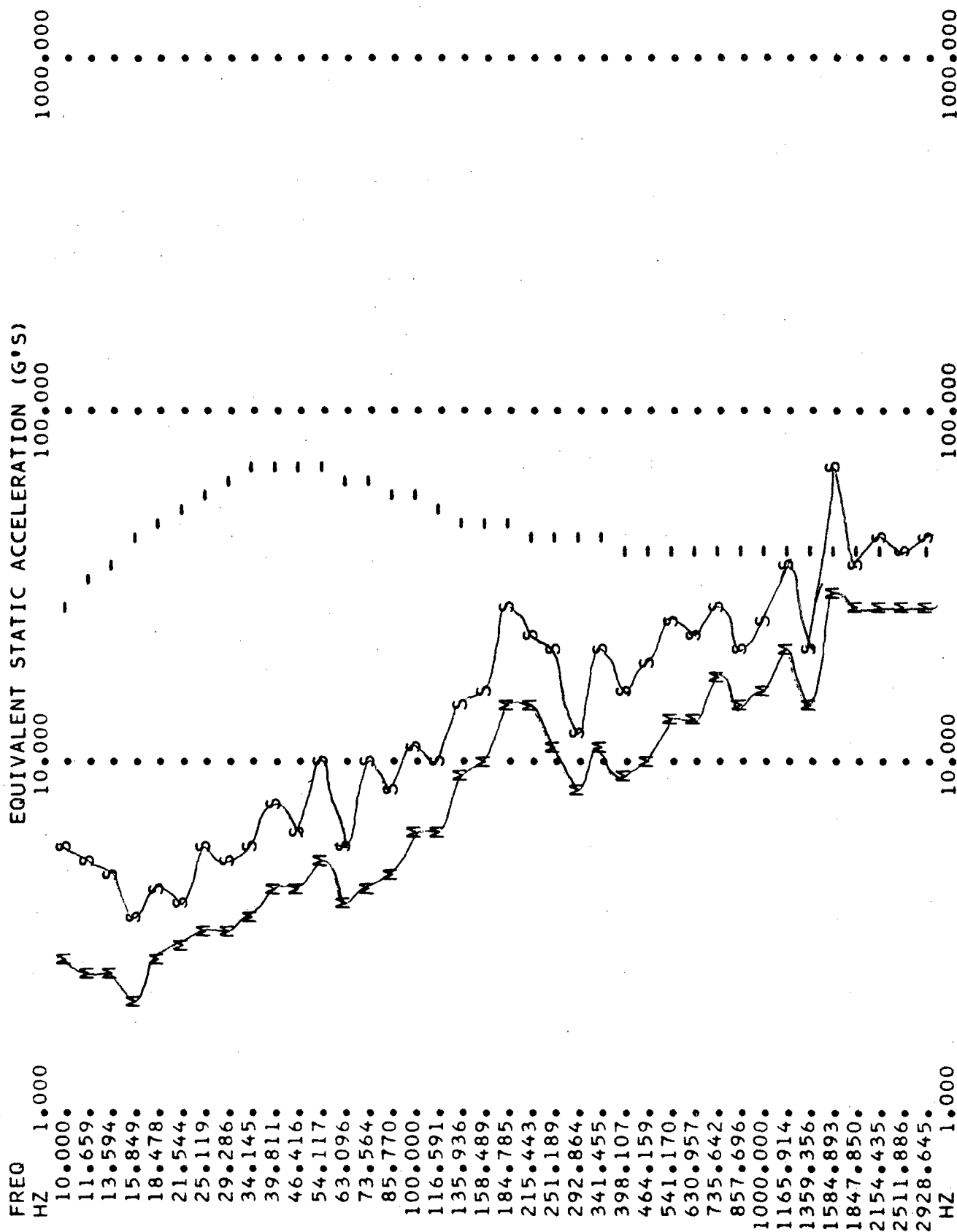
720.00000

55.55556HZ

AVERAGE 8 PTS, SET 1

JULY 77 TTS GUN SHOCKS TURRET ROOF (PERISCOPE INPUT)

TRAN



SHOCK RESPONSE ESA

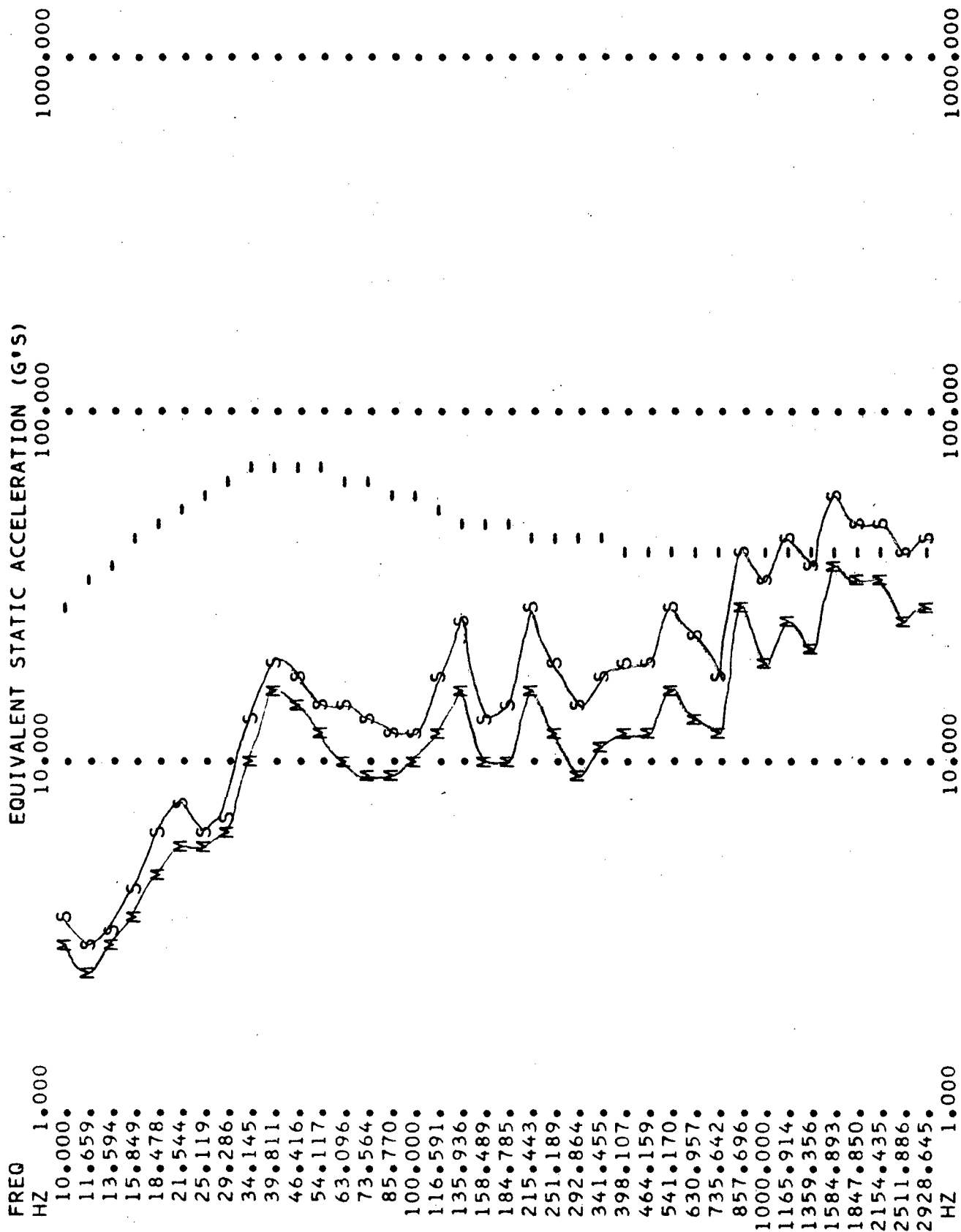
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.023 SECS. DATE 09/01/77 9.6617



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556Hz

AVERAGE	8 PTS, SET 1	JULY 77	TTS	GUN SHOCKS	TURRET	ROOF (PERISCOPE INPUT)	VERT
							VERT

VERT

JULY 77 TTS GUN SHOCKS TURRET ROOF (PERISCOPE INPUT)

8 PTS, SET 1

AVERAGE

The graph displays the Equivalent Static Acceleration (G's) on the y-axis (logarithmic scale from 10,000 to 1,000,000) against Frequency (Hz) on the x-axis (logarithmic scale from 1,000 to 10,000). Two curves are plotted: M (Machine) and S (Structure). Both curves show a general upward trend with increasing frequency, with a significant peak around 10,000 Hz. The S curve consistently shows higher acceleration values than the M curve across the entire frequency range.

FREQ. (Hz)	M (G's)	S (G's)
10,000	10,000	10,000
11,659	11,659	11,659
13,594	13,594	13,594
15,849	15,849	15,849
18,478	18,478	18,478
21,544	21,544	21,544
25,119	25,119	25,119
29,286	29,286	29,286
34,145	34,145	34,145
39,811	39,811	39,811
46,416	46,416	46,416
54,117	54,117	54,117
63,096	63,096	63,096
73,564	73,564	73,564
85,770	85,770	85,770
100,000	100,000	100,000
116,591	116,591	116,591
135,936	135,936	135,936
158,489	158,489	158,489
184,785	184,785	184,785
215,443	215,443	215,443
251,189	251,189	251,189
292,864	292,864	292,864
341,455	341,455	341,455
398,107	398,107	398,107
464,159	464,159	464,159
541,170	541,170	541,170
630,957	630,957	630,957
735,642	735,642	735,642
857,696	857,696	857,696
1,000,000	1,000,000	1,000,000
1,165,914	1,165,914	1,165,914
1,359,356	1,359,356	1,359,356
1,584,893	1,584,893	1,584,893
1,847,850	1,847,850	1,847,850
2,154,435	2,154,435	2,154,435
2,511,886	2,511,886	2,511,886
2,928,645	2,928,645	2,928,645

M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

55.55556H;

720.00000

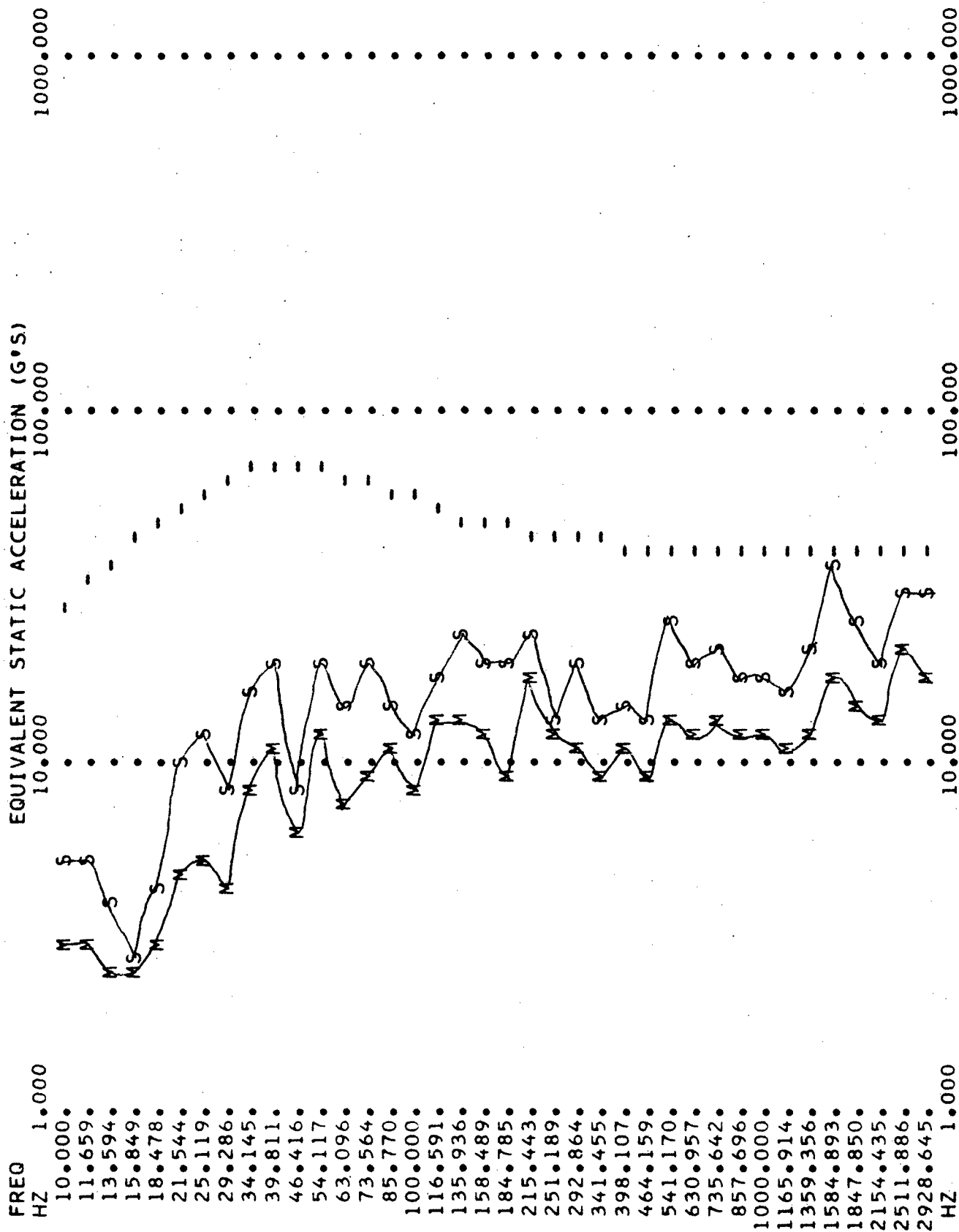
40.00000 G, AT 18.00000 MSEC, SEVERITY=

- SPECIFICATION CURVE,

DDMM TIME 0 MINS 0.022 SFCSS. DATE 09/01/77 9.6617

AVERAGE 7 PTS, SET 1

JULY 77 TTS GUN SHOCKS TURRET RIGHT WALL (LIGHT ELBOW INPUT) TRAN



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

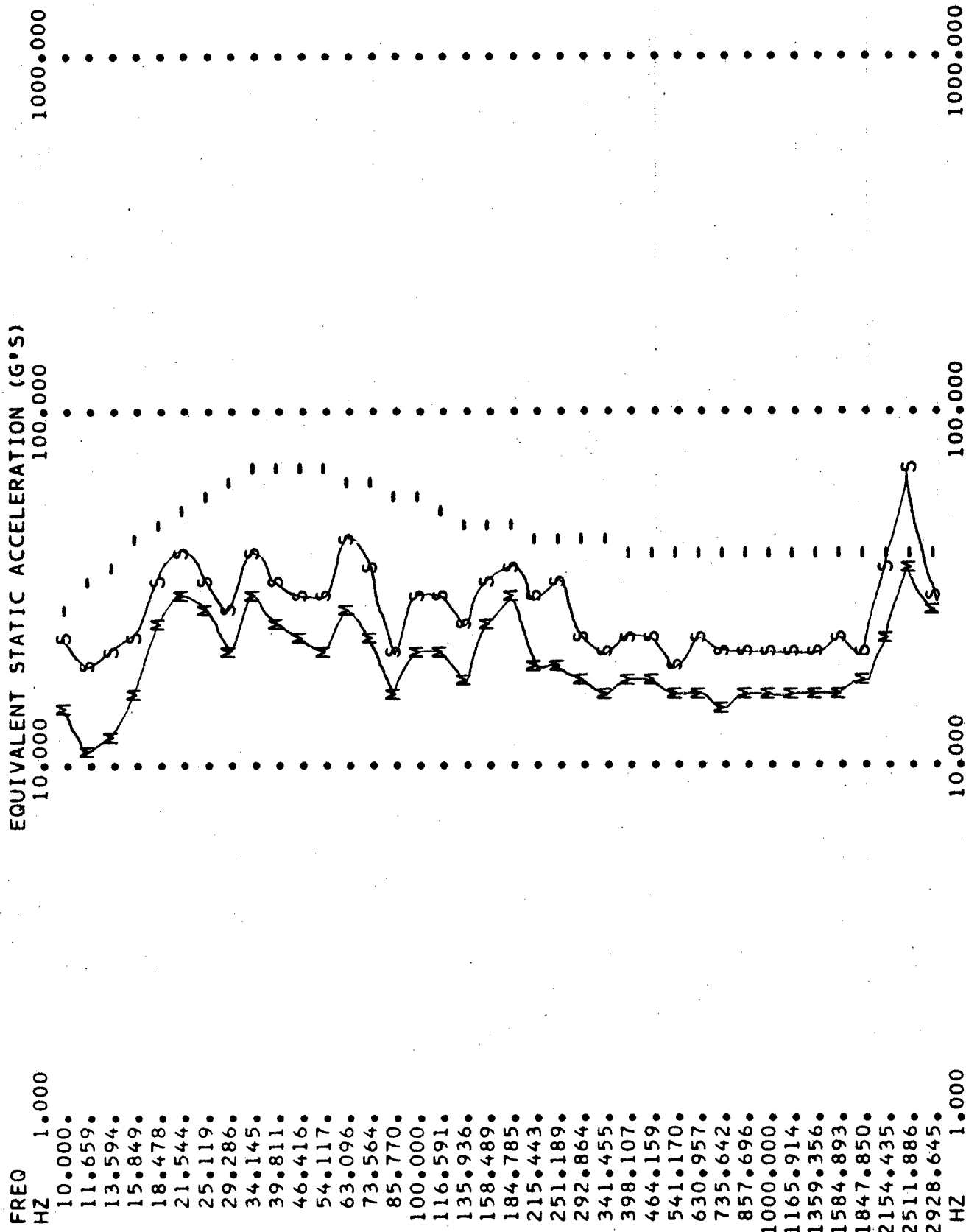
40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.023 SECS. DATE 09/01/77

Q-6617



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

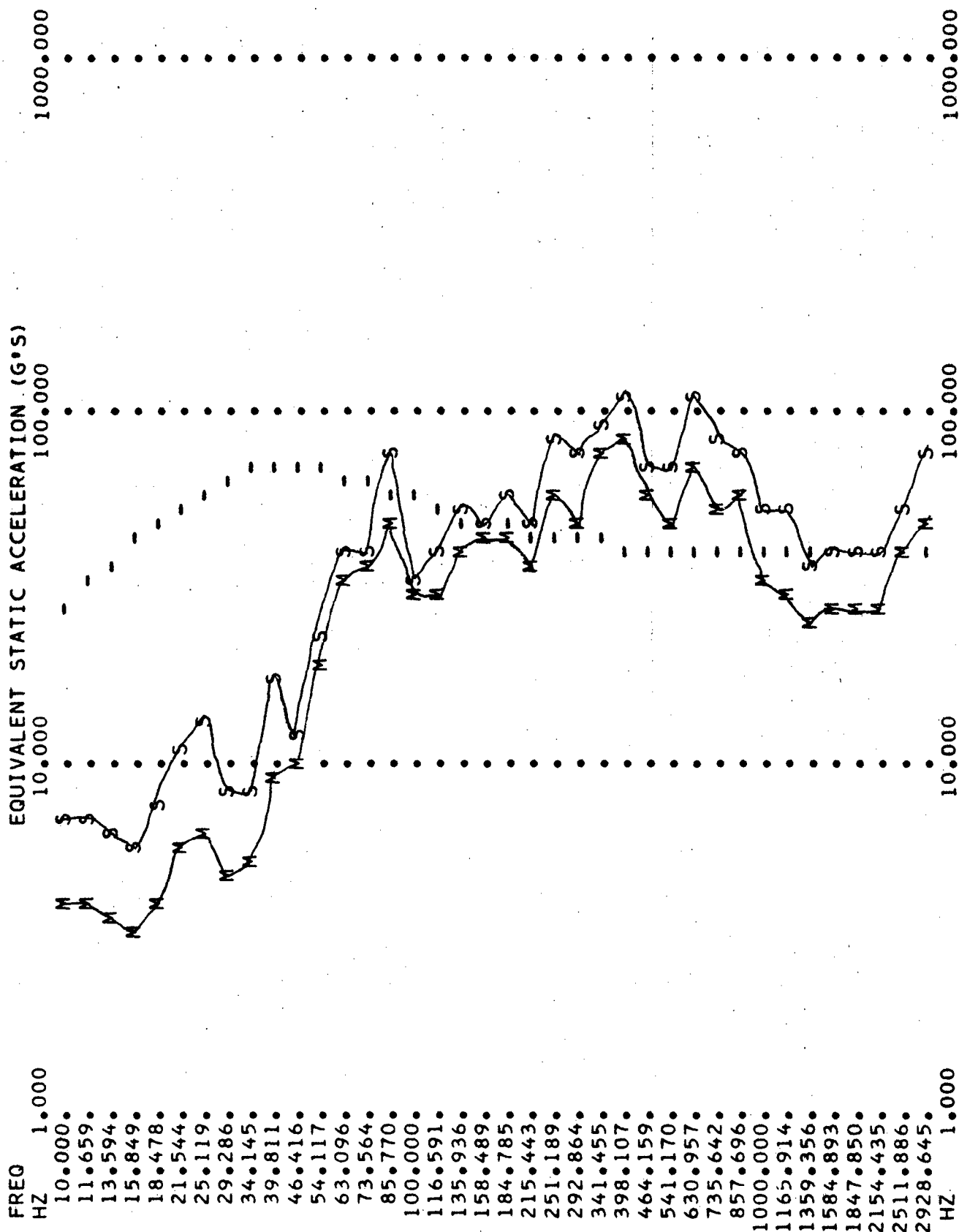
55.555556H

AVERAGE 7 PTS, SET 1

JULY 77 TTS GUN SHOCKS

TTS FLANGE

TRAN



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.024 SECS. DATE 09/01/77 9.6617

AVERAGE 6 PTS, SET 1

JULY 77 TTS GUN SHOCKS

TTS FLANGE

VERT

FREQ
HZ 1.000

EQUIVALENT STATIC ACCELERATION (G'S)

1000.000

100.000

10.000

10.000

11.659

13.594

15.849

18.478

21.544

25.119

29.286

34.145

39.811

46.416

54.117

63.096

73.564

85.770

100.000

116.591

135.936

158.489

184.785

215.443

251.189

292.864

341.455

398.107

464.159

541.170

630.957

735.642

857.696

1000.000

1165.914

1359.356

1584.893

1847.850

2154.435

2511.886

2928.645

1.000

100.000

10.000

10.000

M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

-- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H

RUN TIME 0 MINS 0.023 SECS. DATE 09/01/77

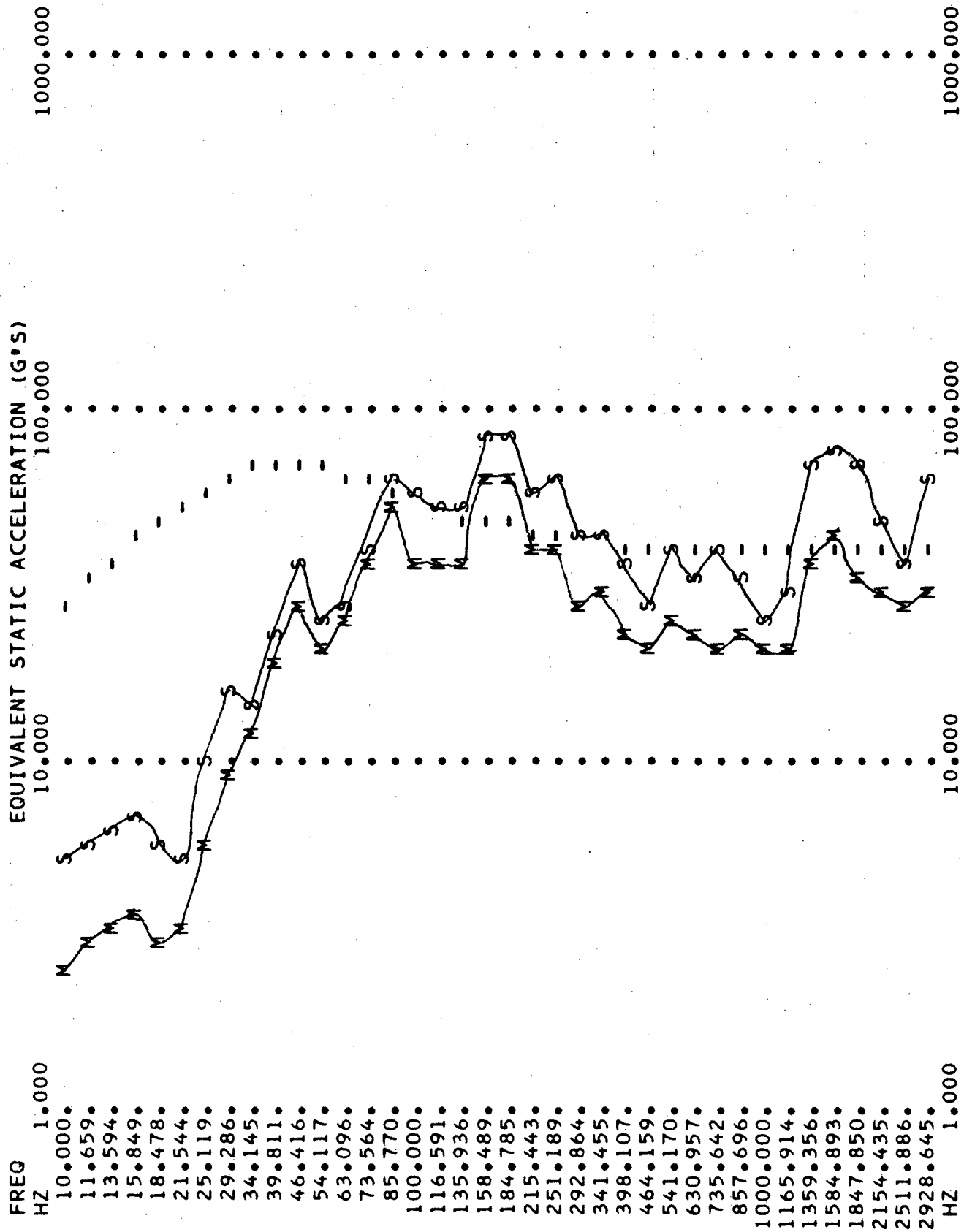
9.6617

LONG

TTS FLANGE

JULY 77 TTS GUN SHOCKS

AVERAGE 6 PTS, SET 1



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

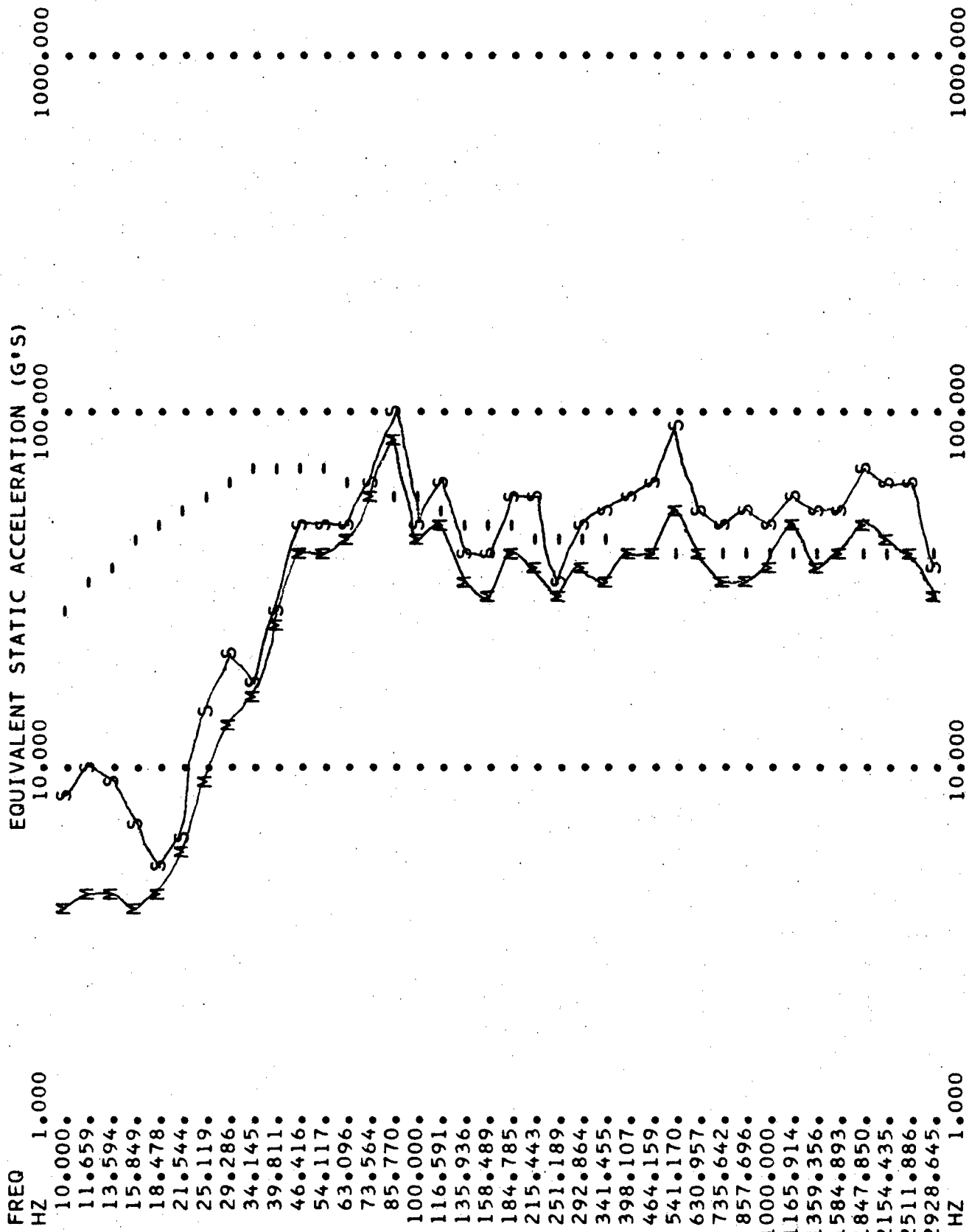
40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H:

RUN TIME 0 MINS 0.023 SFCS. DATE 09/01/77

9.6617



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

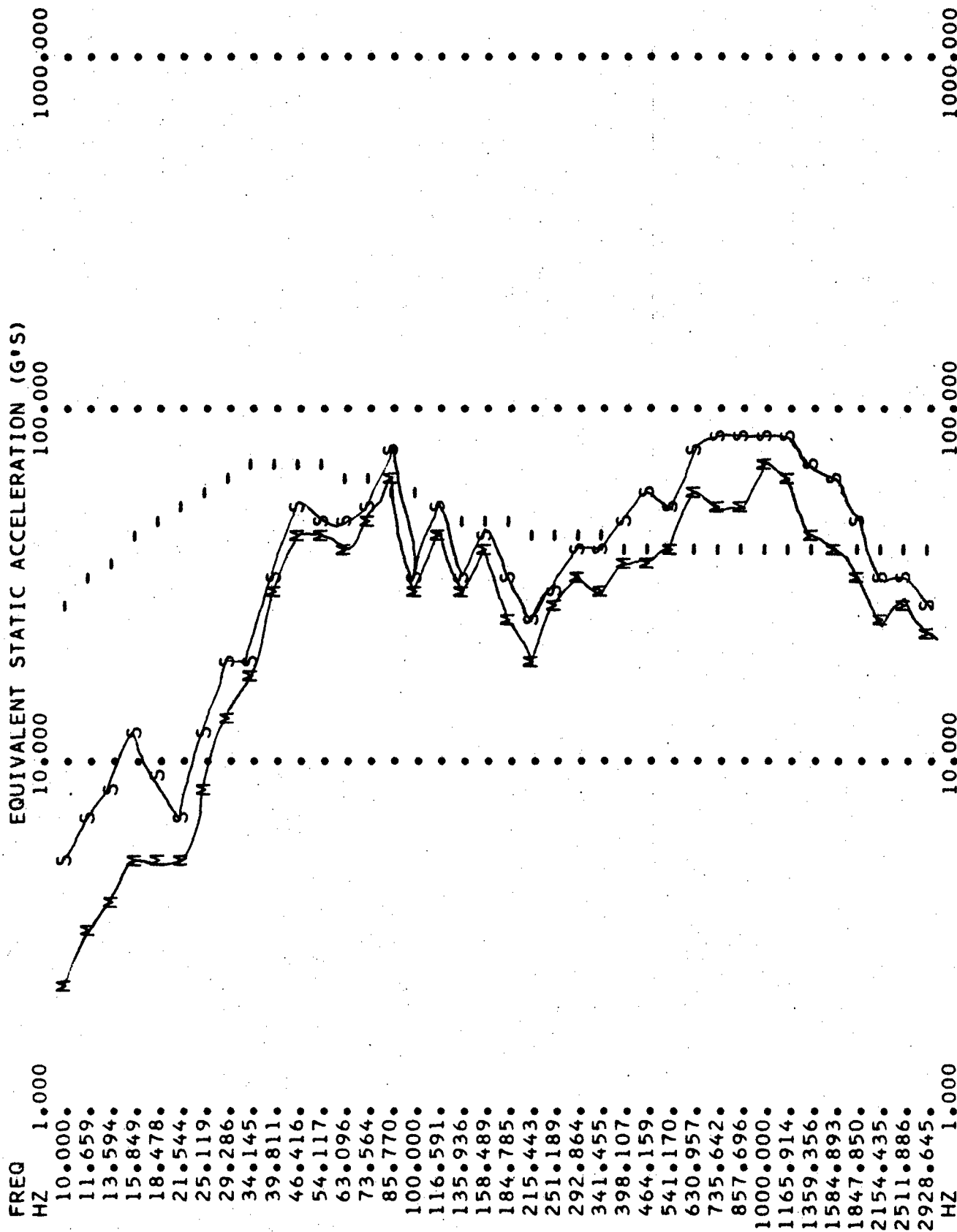
- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.555556HZ

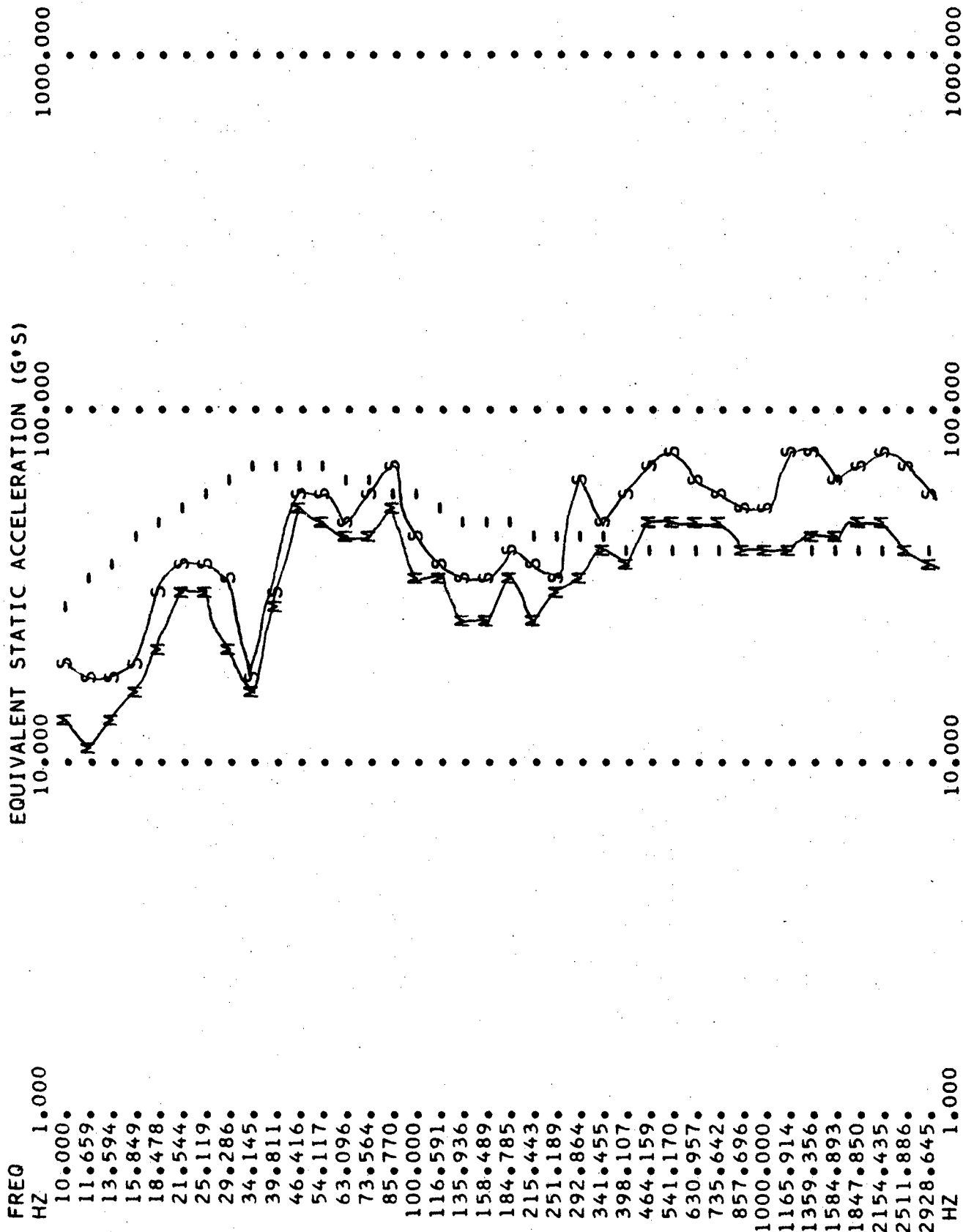
AVERAGE 5 PTS, SET 1 JULY 77 TTS GUN SHOCKS NO-BAK HOUSING (LIGHT ELBOW INPUT) LONG



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.55556HZ

RUN TIME 0 MINS 0.048 SECS. DATE 09/01/77 15.1330

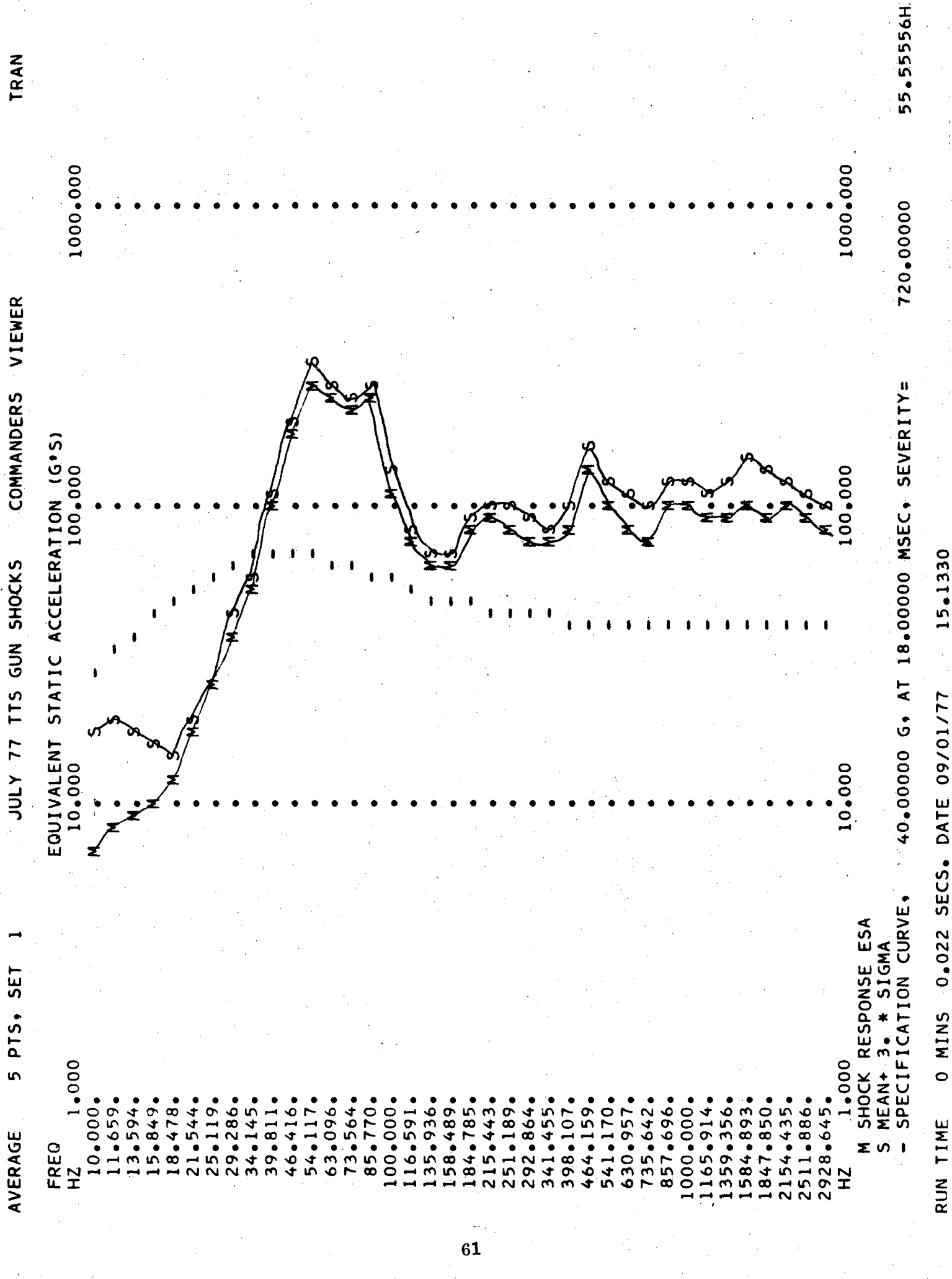


M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

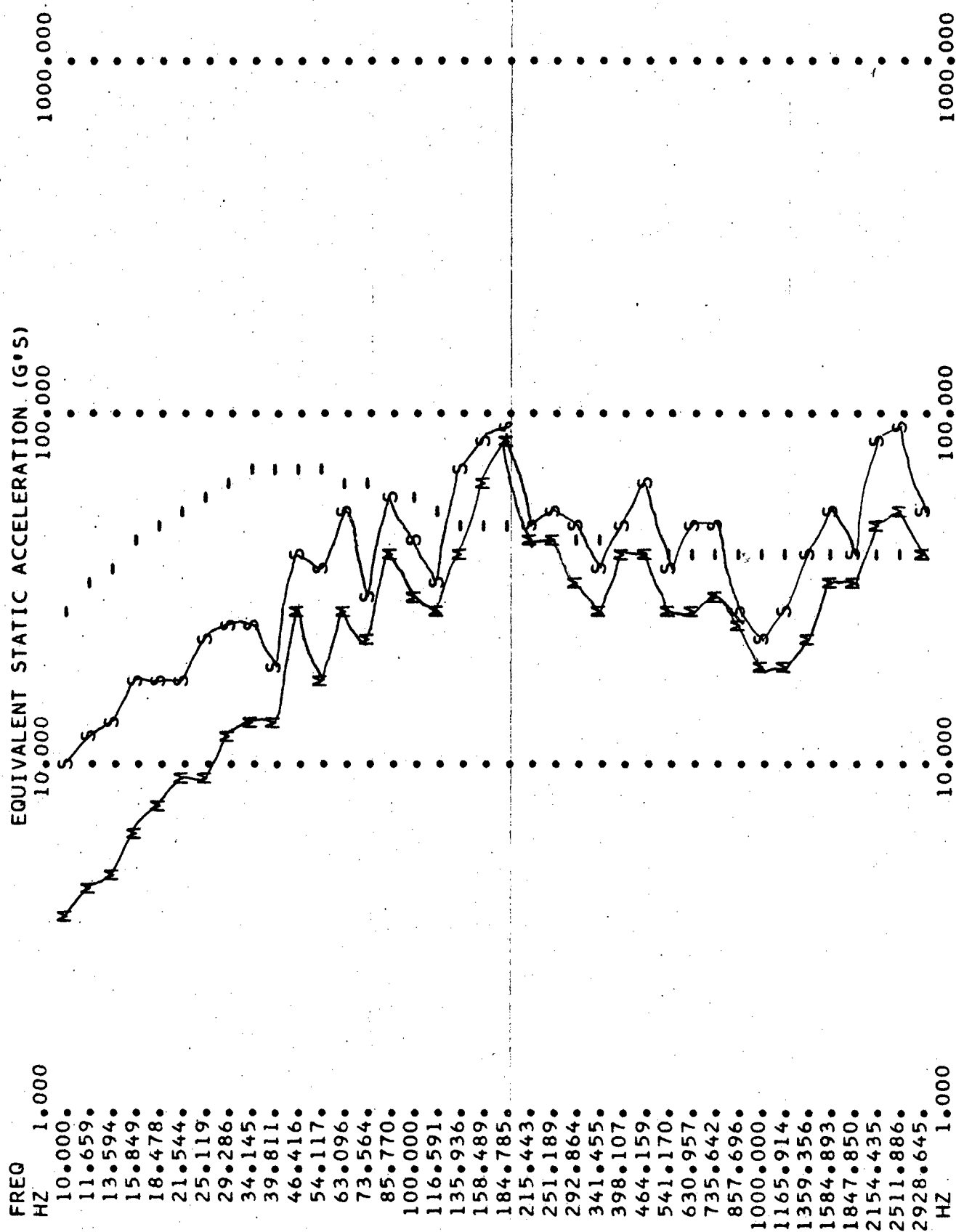
- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556H



AVERAGE 5 PTS, SET 1 JULY 77 TTS GUN SHOCKS COMMANDERS VIEWER LONG



M SHOCK RESPONSE ESA

S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE,

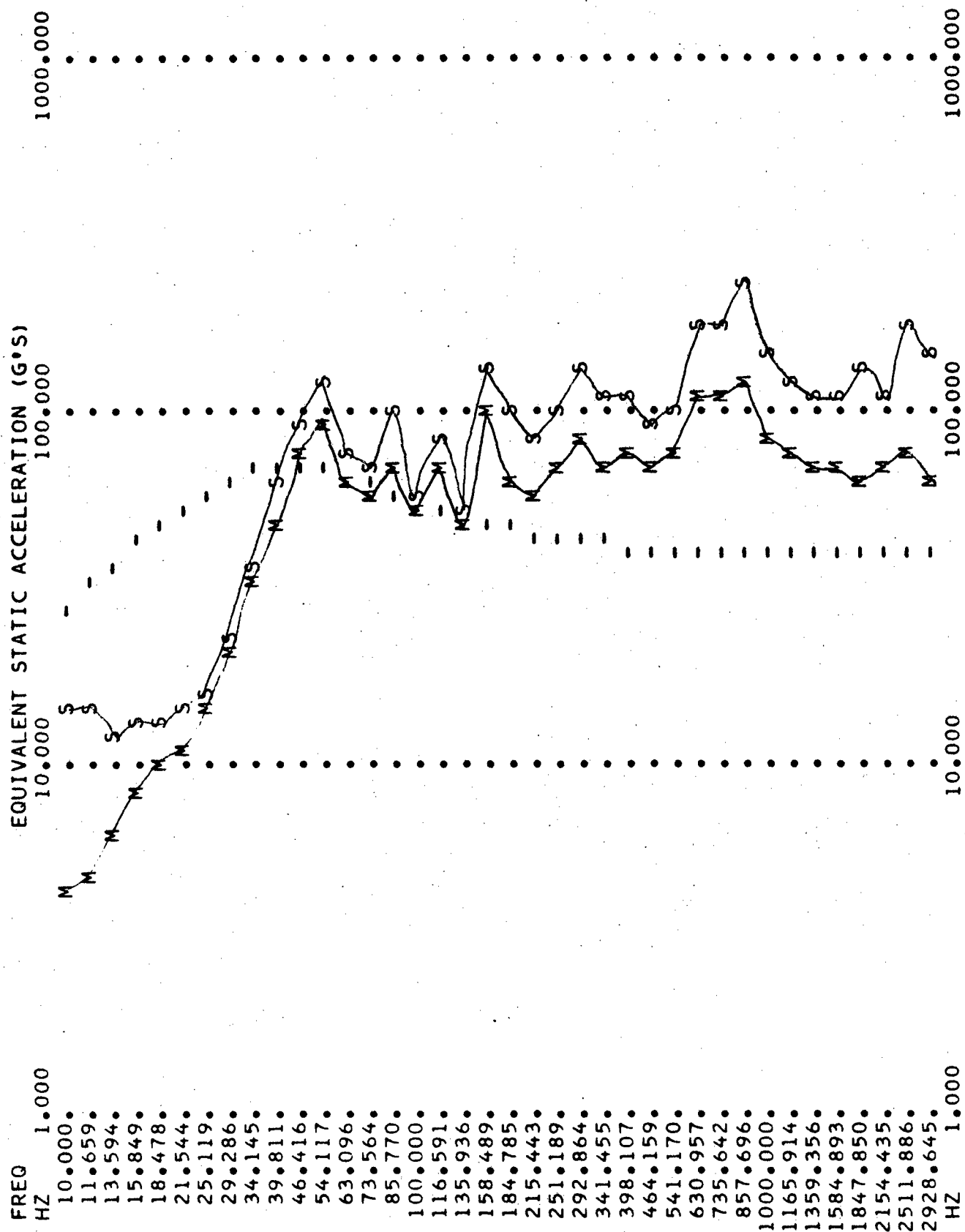
40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.555561

RUN TIME 0 MINS 0.022 SECS. DATE 09/01/77 15.1330

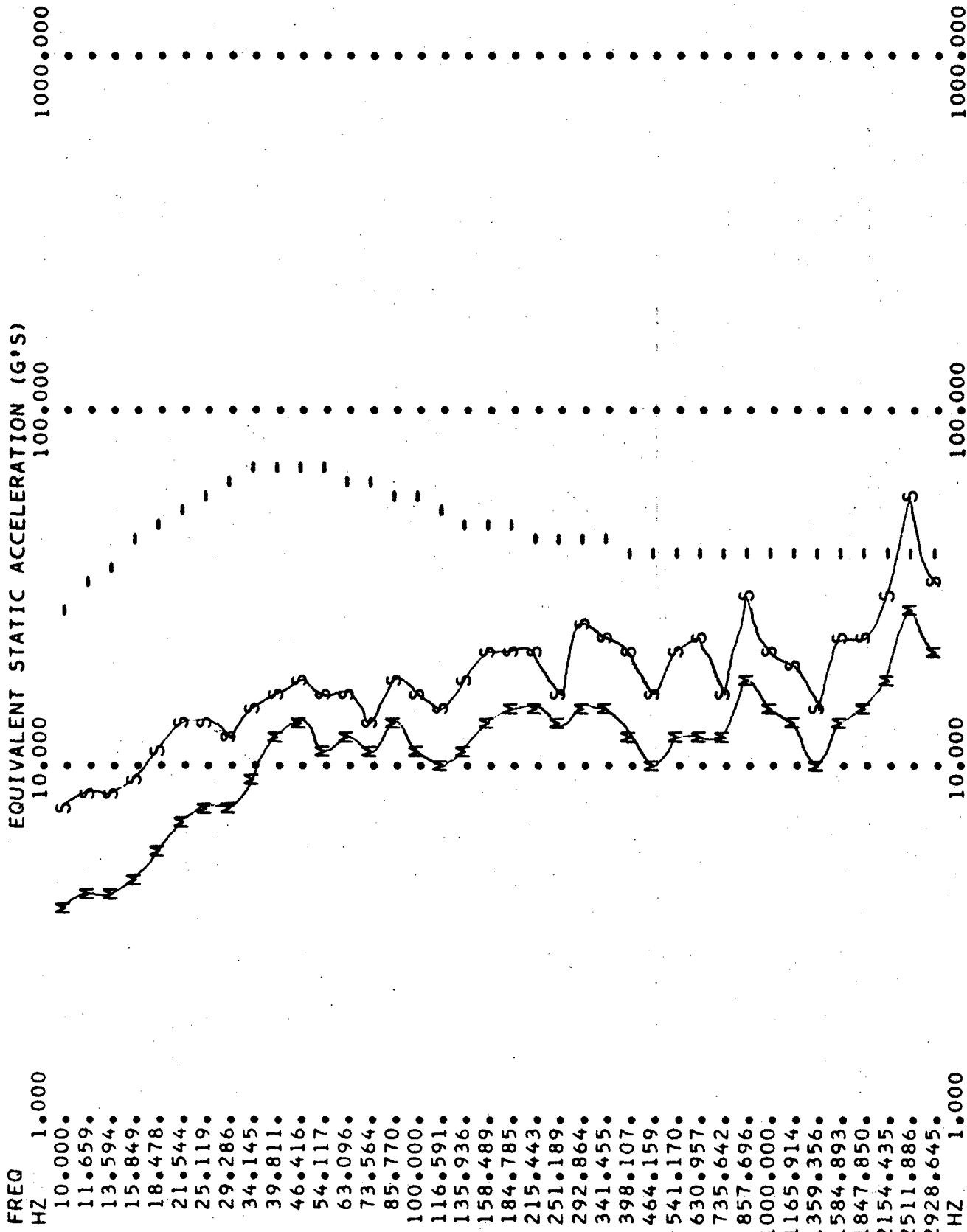
AVERAGE 5 PTS, SET 1 JULY 77 TTS GUN SHOCKS COMMANDERS VIEWER VERT



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.55556HZ

DIN TIME 0 MINS 0.023 SECS. DATE 09/01/77 15.1330

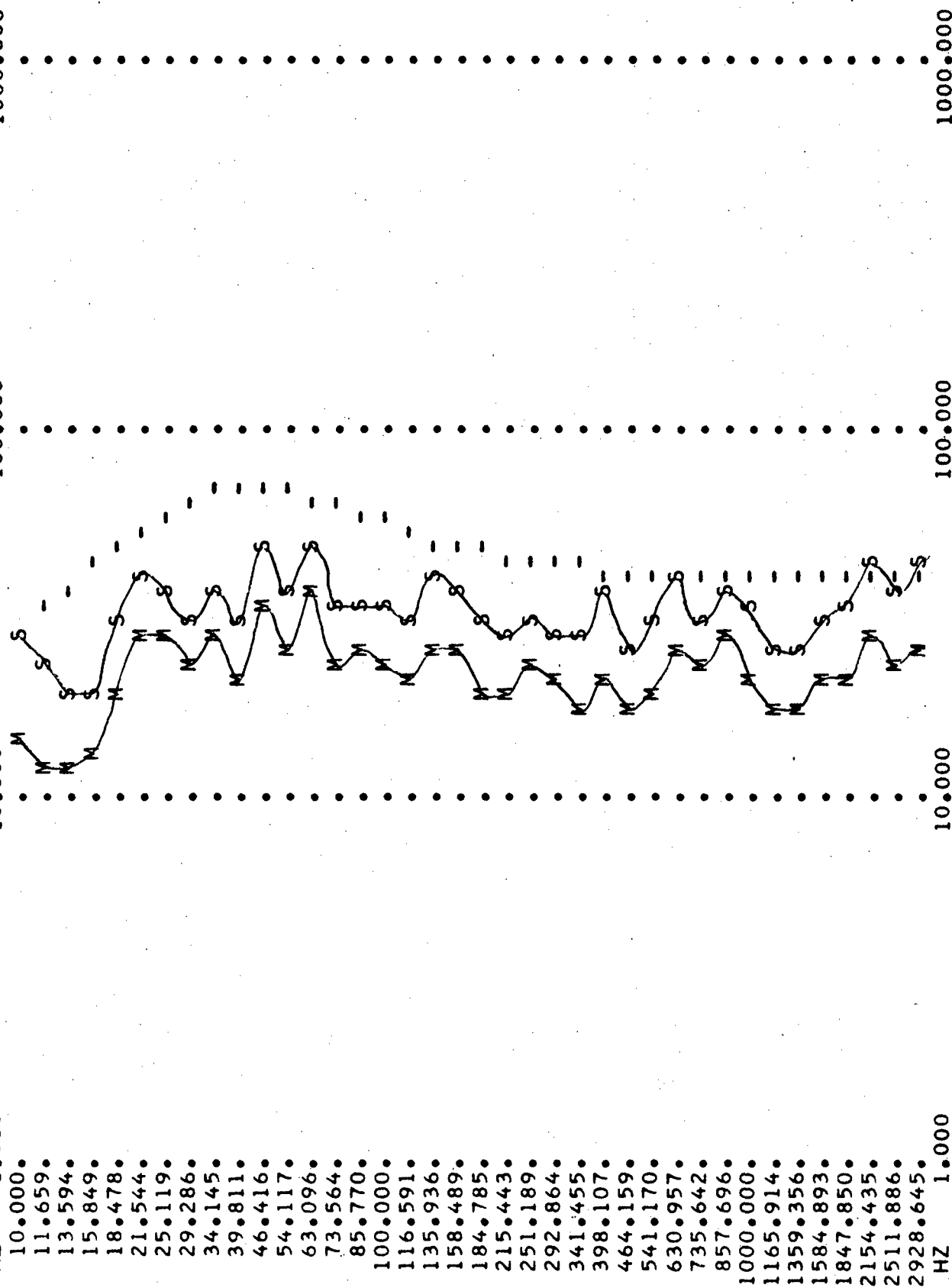


M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.55556HZ

JULY 77 TTS GUN SHOCKS TURRET BUSTLE ROOF (PWR.CONV.INPUT) LONG

EQUIVALENT STATIC ACCELERATION (G'S)



S MEAN+ 3. * SIGMA

40.00000 G, AT 18.00000 MSEC, SEVERITY=

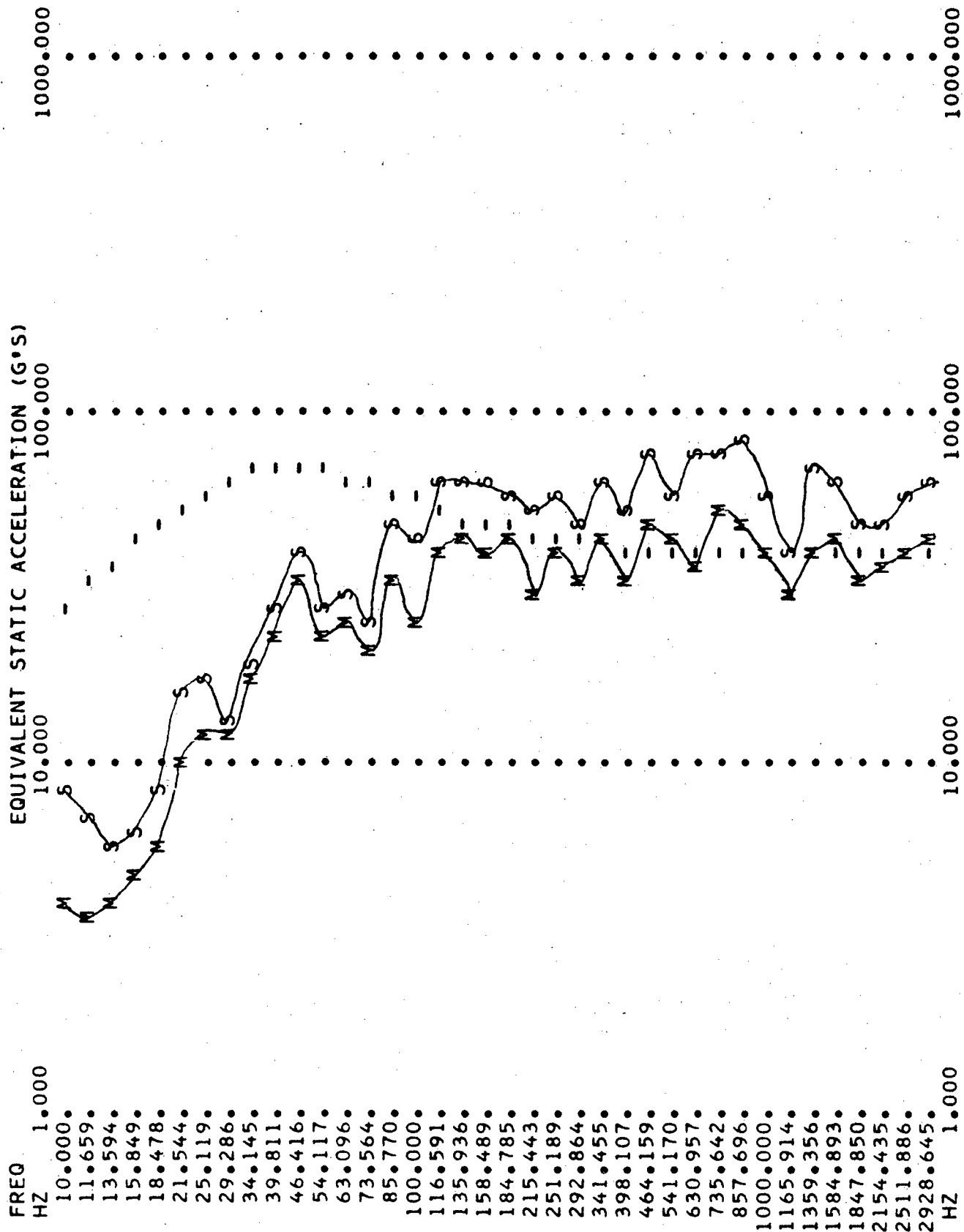
720.00000

55.55556HZ

RUN TIME 0 MINS 0.024 SECS. DATE 09/01/77 9.6617

AVERAGE 8 PTS. SET 1

JULY 77 TTS GUN SHOCKS TURRET BUSTLE ROOF (PWR.CONV.INPUT) VERT



M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

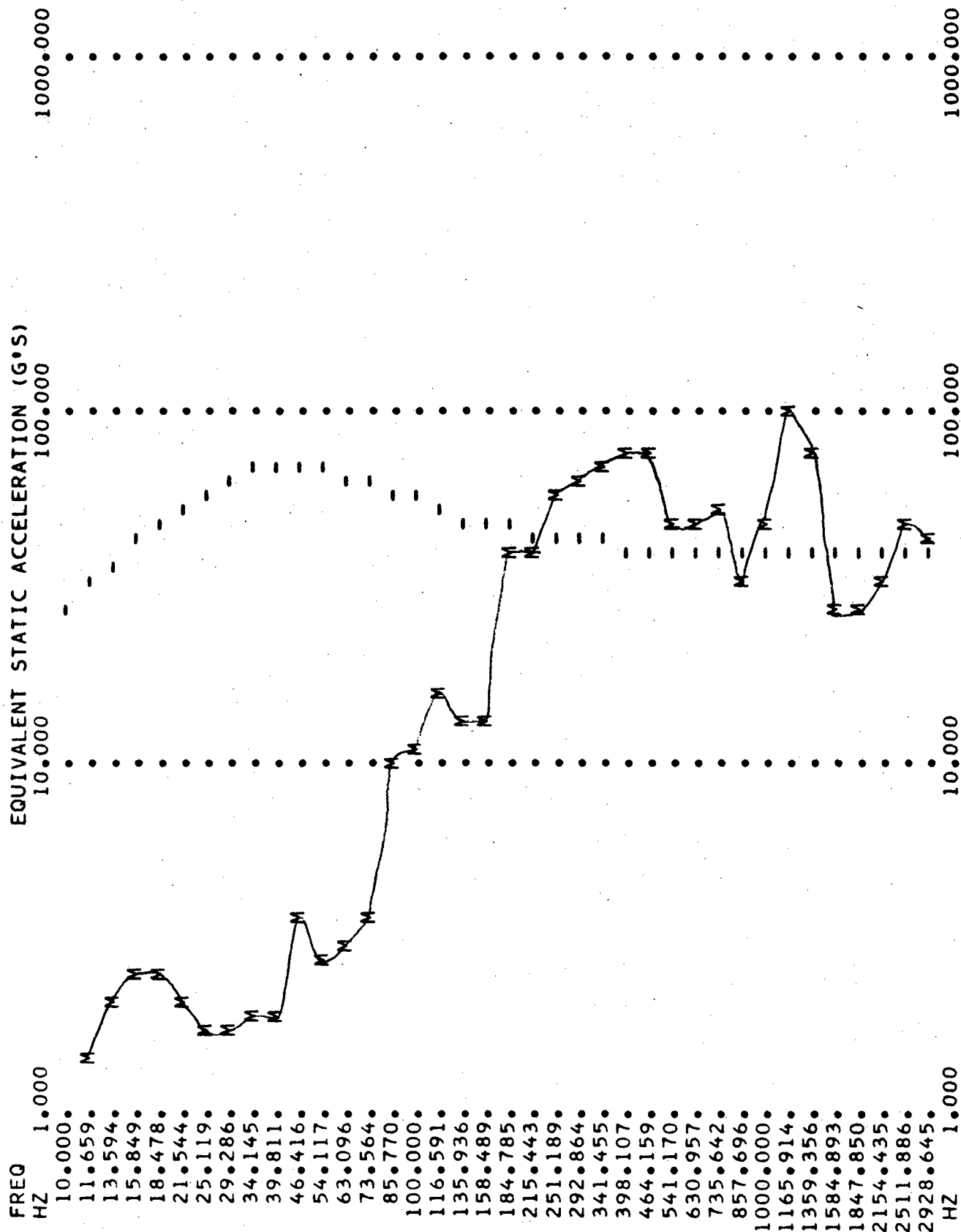
- SPECIFICATION CURVE,

40.00000 G, AT 18.00000 MSEC, SEVERITY=

720.00000

55.55556HZ

RUN TIME 0 MINS 0.025 SECS. DATE 09/01/77 9.6617



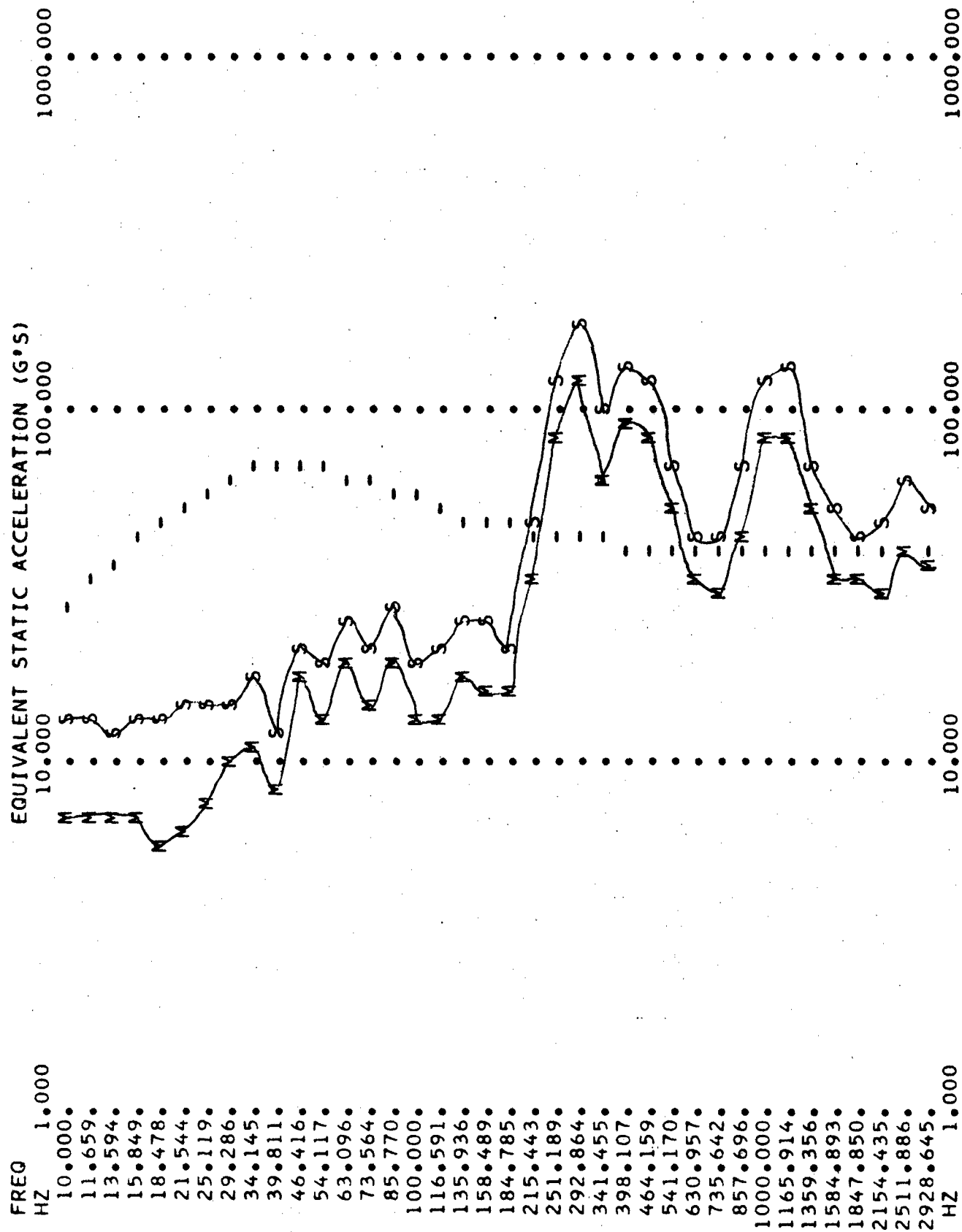
M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

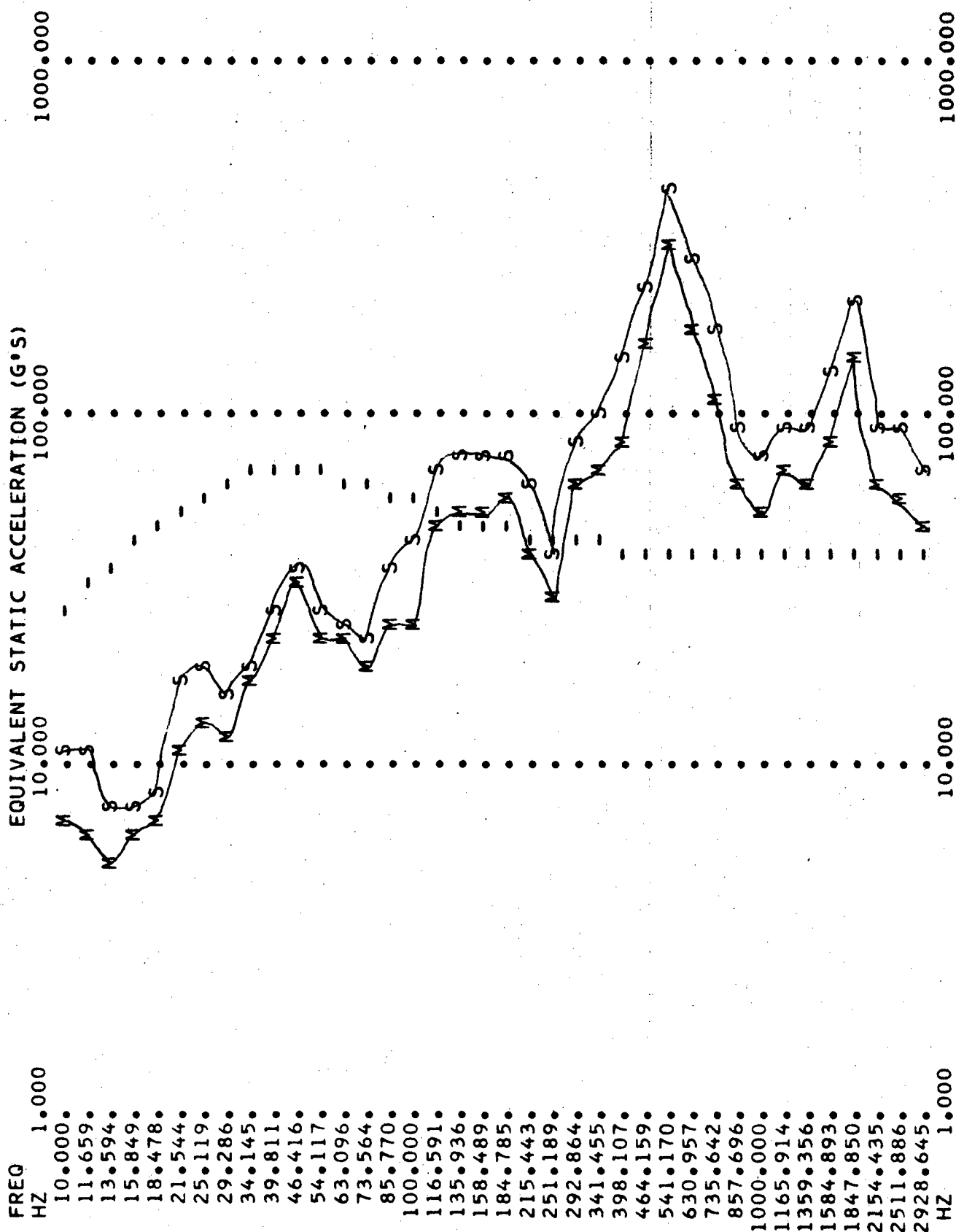
- SPECIFICATION CURVE, 40.00000 G, AT 18.00000 MSEC, SEVERITY= 720.00000 55.555556HZ

AVERAGE 6 PTS, SET 1

JULY 77 TTS GUN SHOCKS POWER CONVERTER HOUSING.

LONG





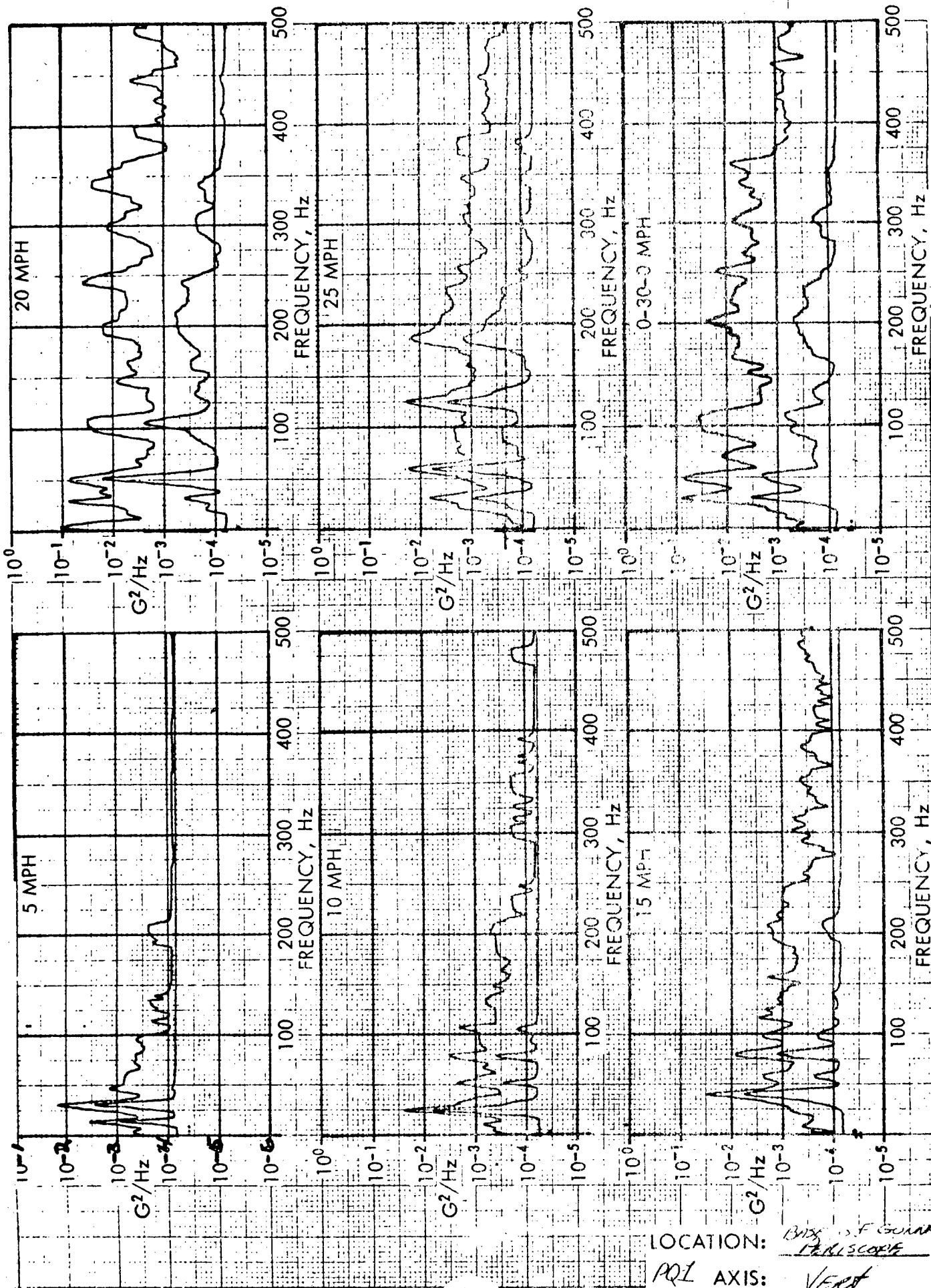
M SHOCK RESPONSE ESA
S MEAN+ 3. * SIGMA

APPENDIX B

HARD SURFACE AND CROSS COUNTRY VIBRATION POWER SPECTRA DENSITIES PLOTS

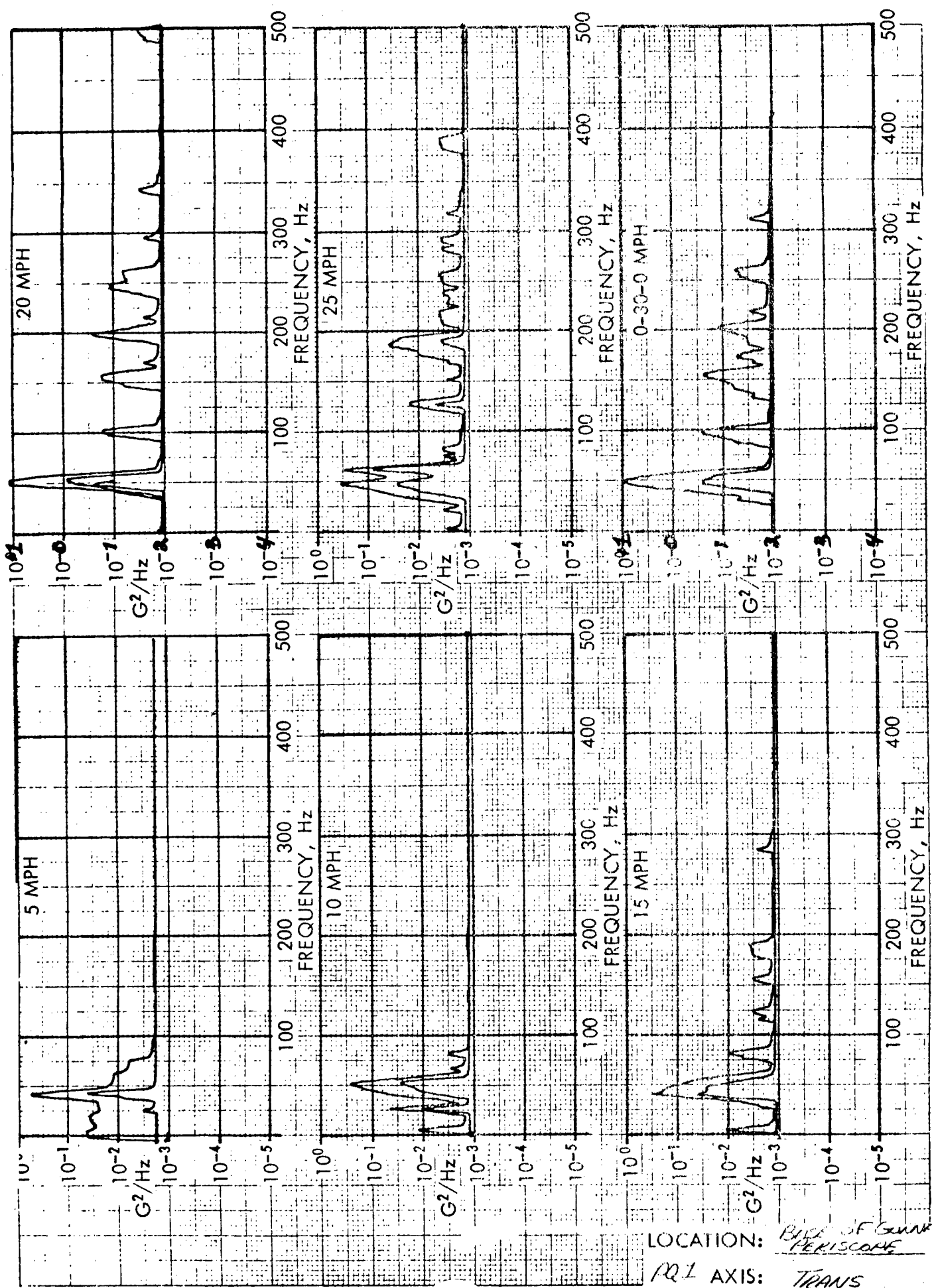
ROAD VIBRATION P.S.D. PLOTS
ON TEST VEHICLE PQ-1
PAVED SURFACE
(CONDITION 1)

173 Vib
PO1 LOC 1 VERT



LOCATION: Bldg 5, F Gunner's
PO1 AXIS: PARALSCOPE VERT

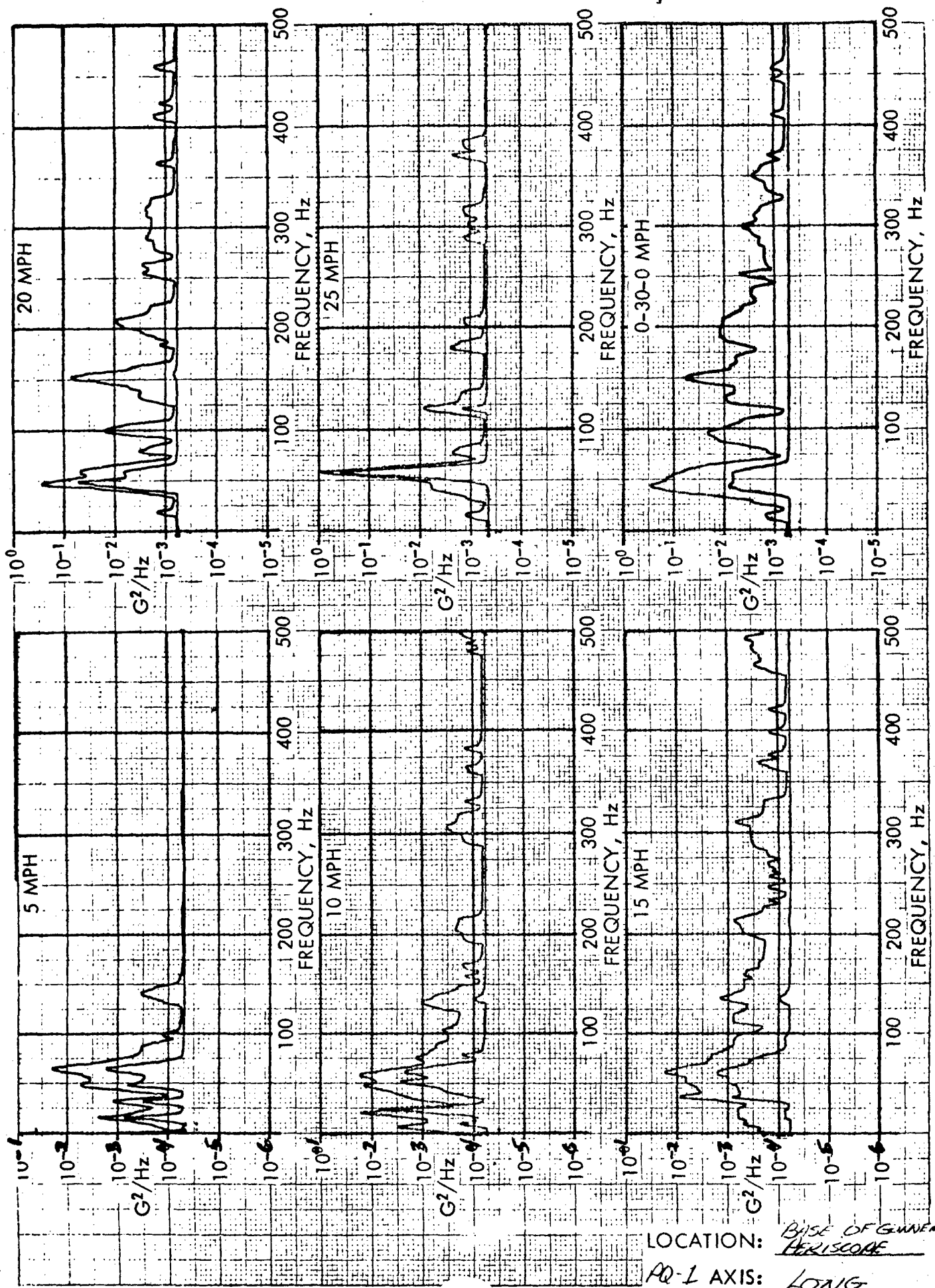
Ap1 Loc I Trans axis



LOCATION: BACK OF GUNNERS PERISCOPE
AQ1 AXIS: TRANS

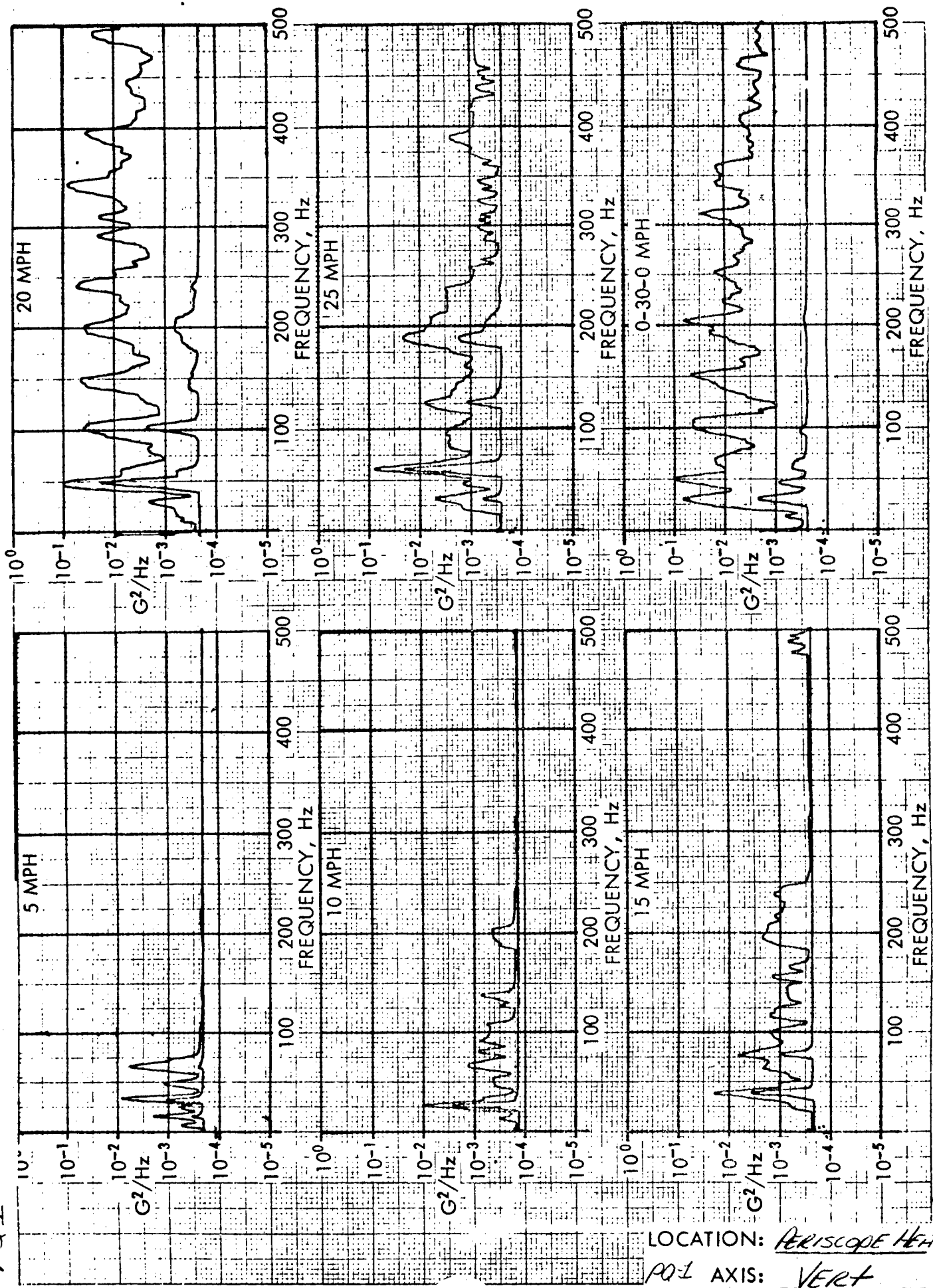
TTS VIB

PQ-1 LOC 1 LONG AXIS



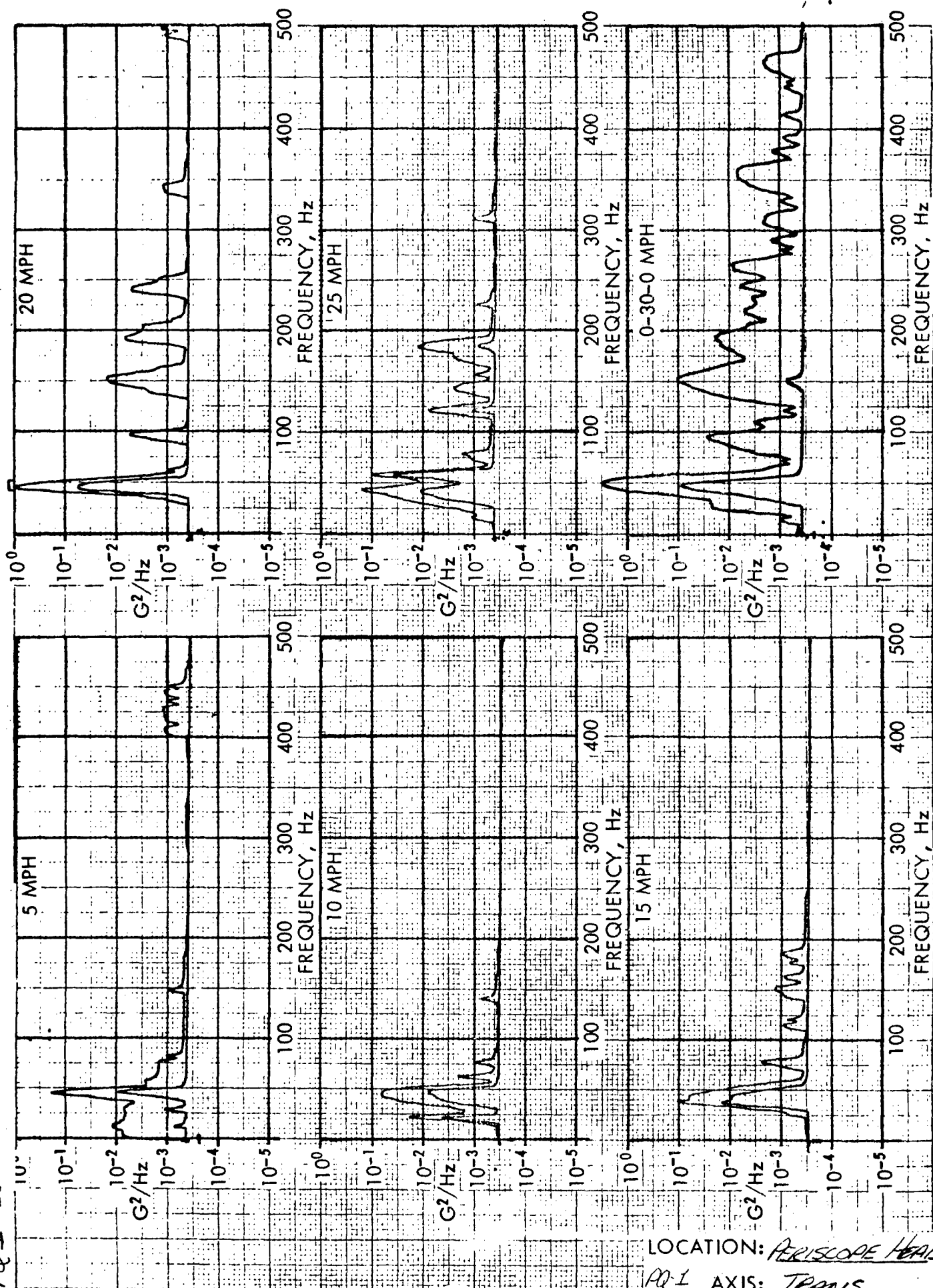
LOCATION: BASE OF GUNNERS PERISCOPE
PQ-1 AXIS: LONG

775 V13
 PQ1 LOC 2 VERT



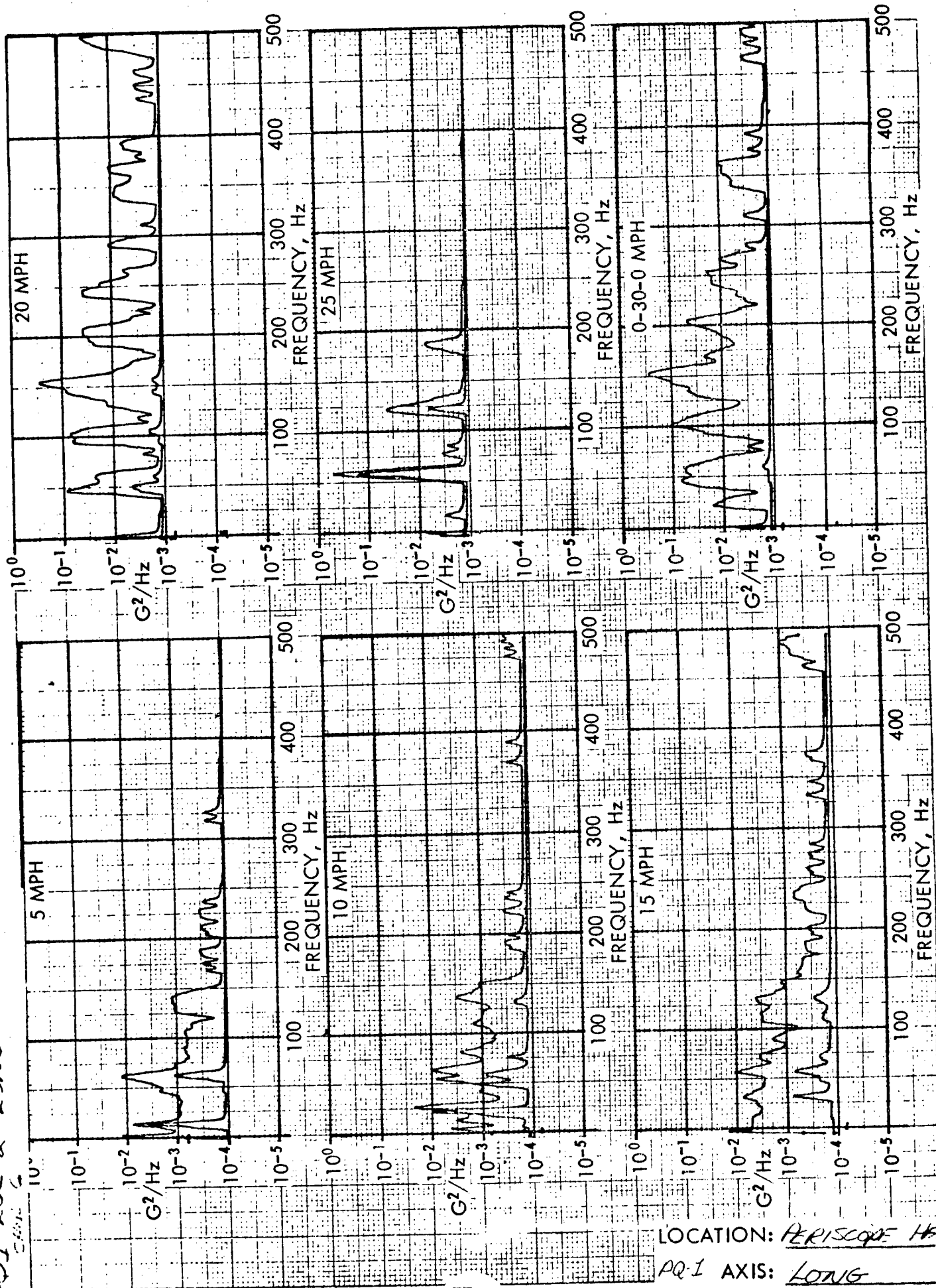
LOCATION: PERISCOPE HEAD
 PQ-1 AXIS: VERT

775 V16
 PQ1 Loc 2 Trans



LOCATION: PERISCOPE HEAD
 PQ1 AXIS: TRANS

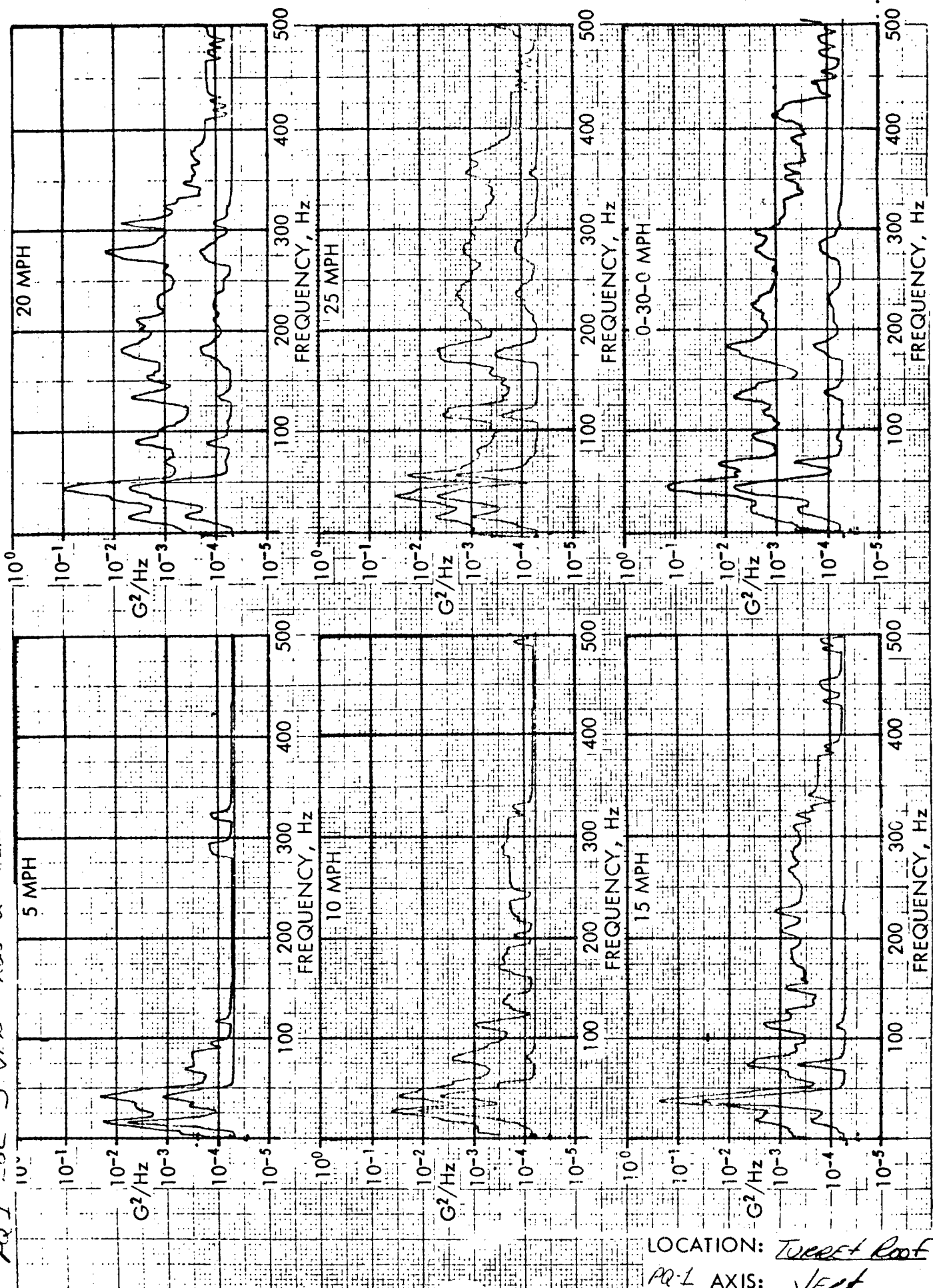
775 V-5
 PQ1 Loc 2 LONG



LOCATION: PERISCOPE HEAD
 PQ-1 AXIS: LONG

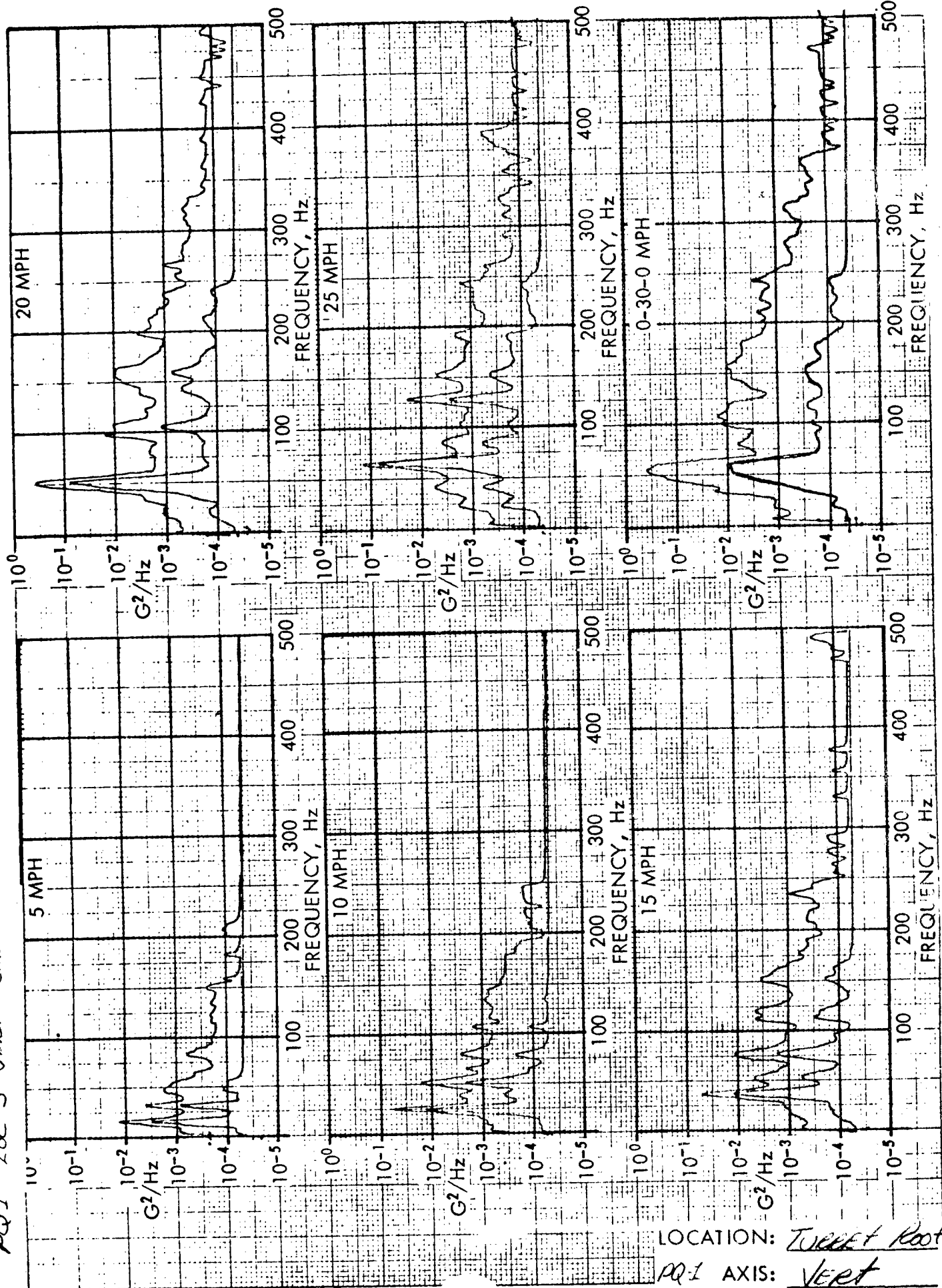
775 VIB

PQ1 LOC 3 VERT Run 2 Cont 14



LOCATION: Tweet Roof
PQ-1 AXIS: VERT

TTS VIB
PQ1 LOC 3 VERT CHNL 14

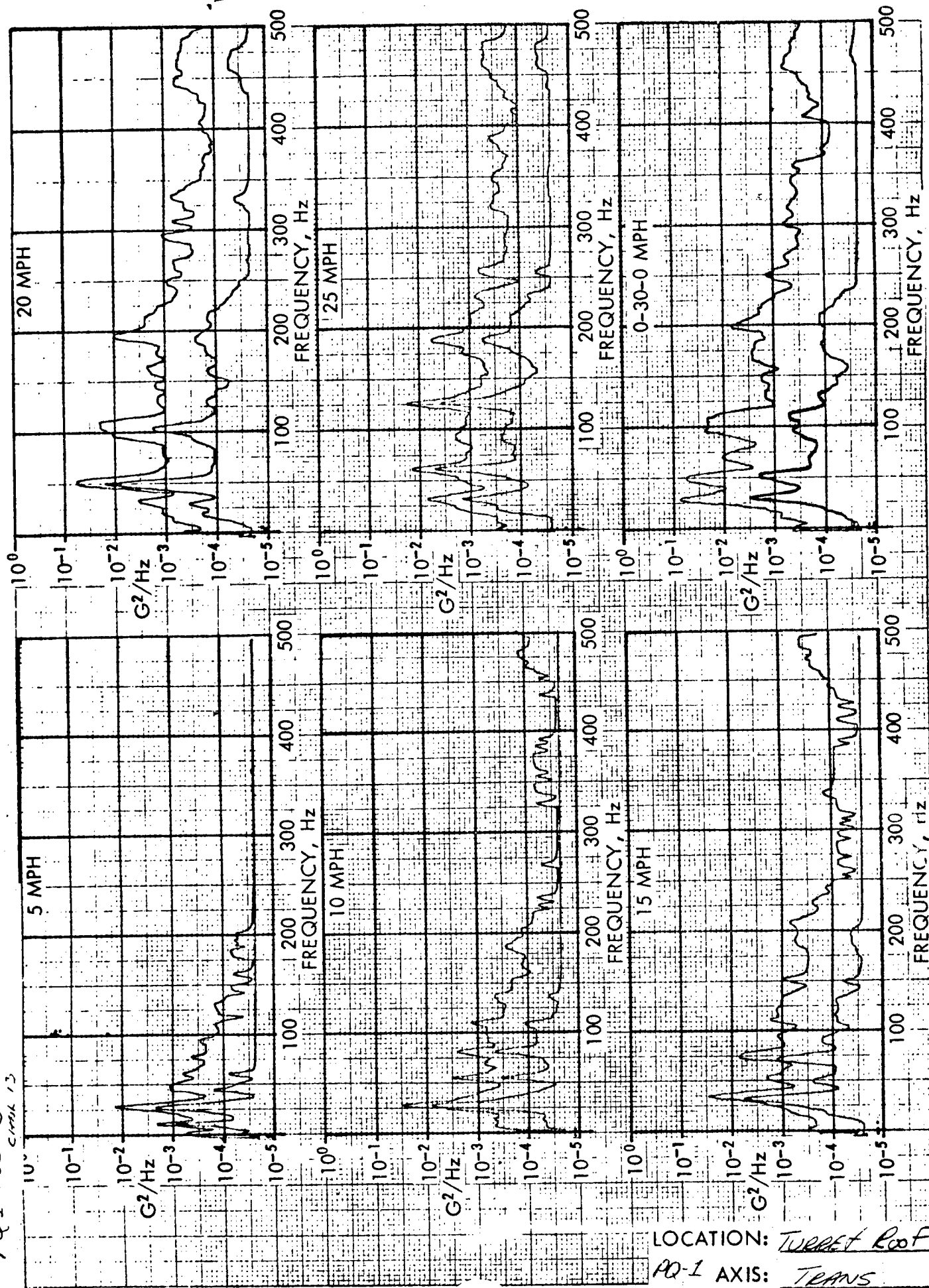


LOCATION: TUGGET ROOF
PQ-1 AXIS: VERT

TTS V16

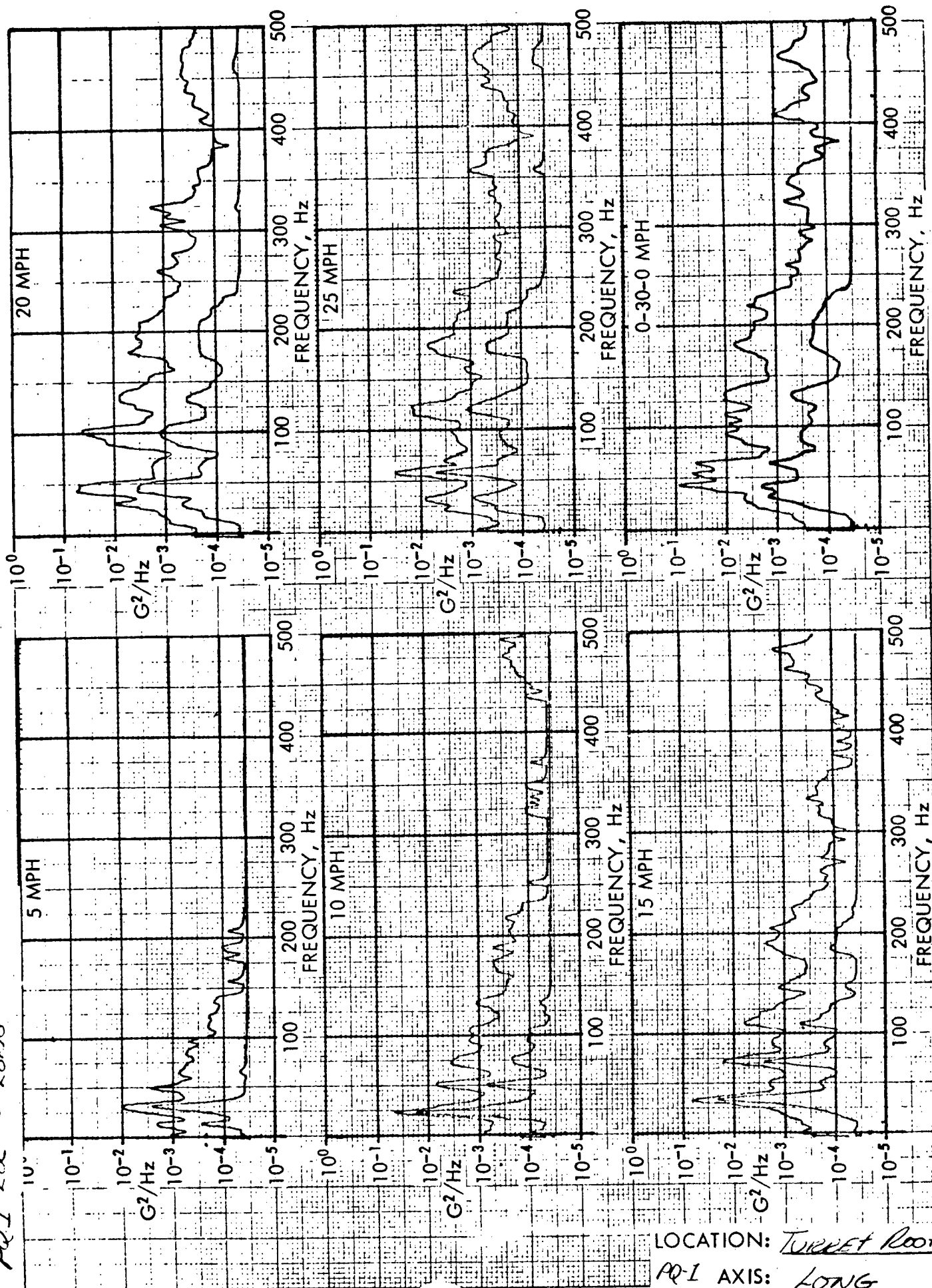
PQ1 Loc 3 Trans

CH 13



LOCATION: TURRET ROOF
PQ-1 AXIS: TRANS

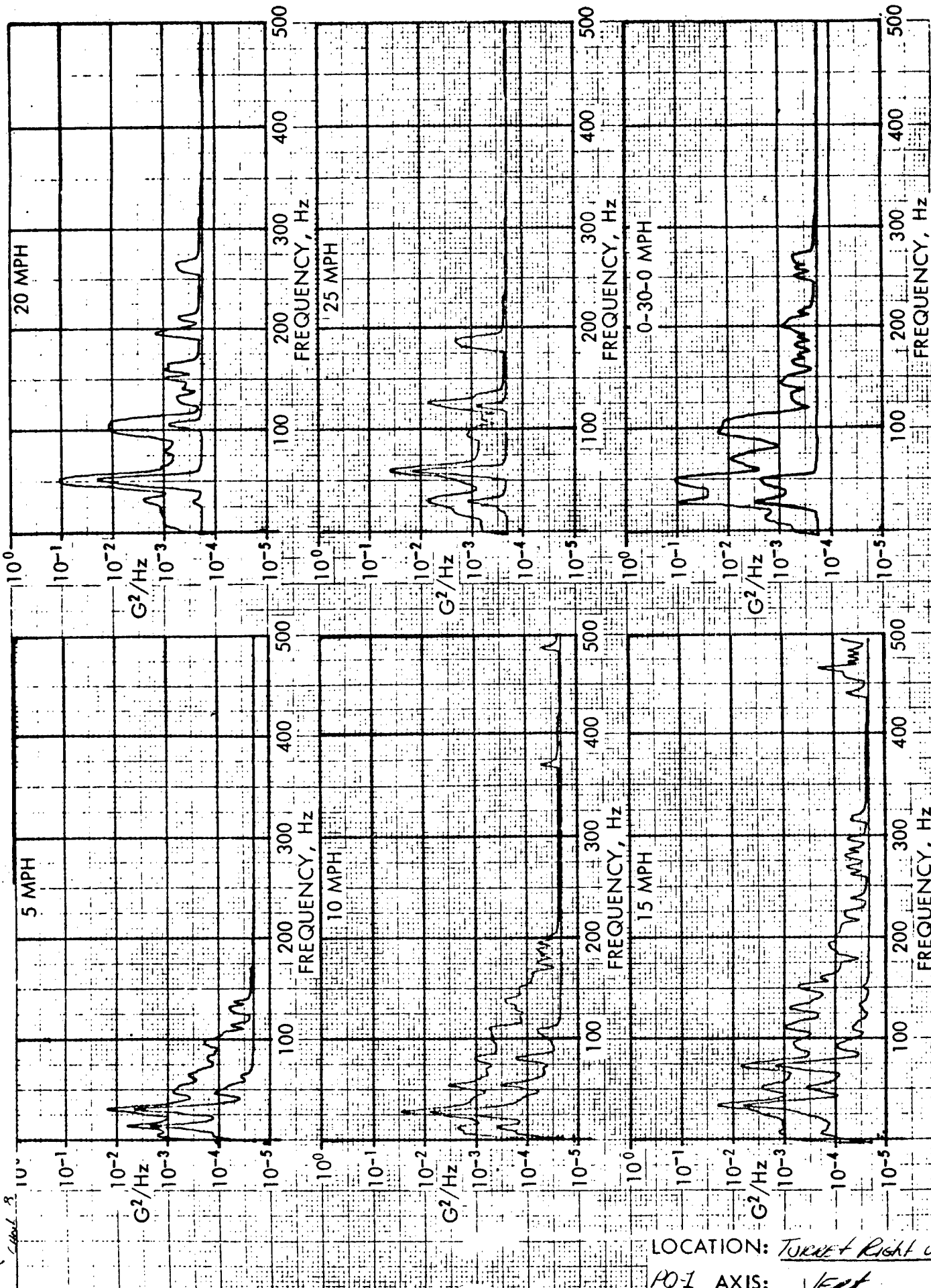
TTS V16
 PQ1 Loc 3 Long



LOCATION: TURRET ROOF
 PQ1 AXIS: LONG

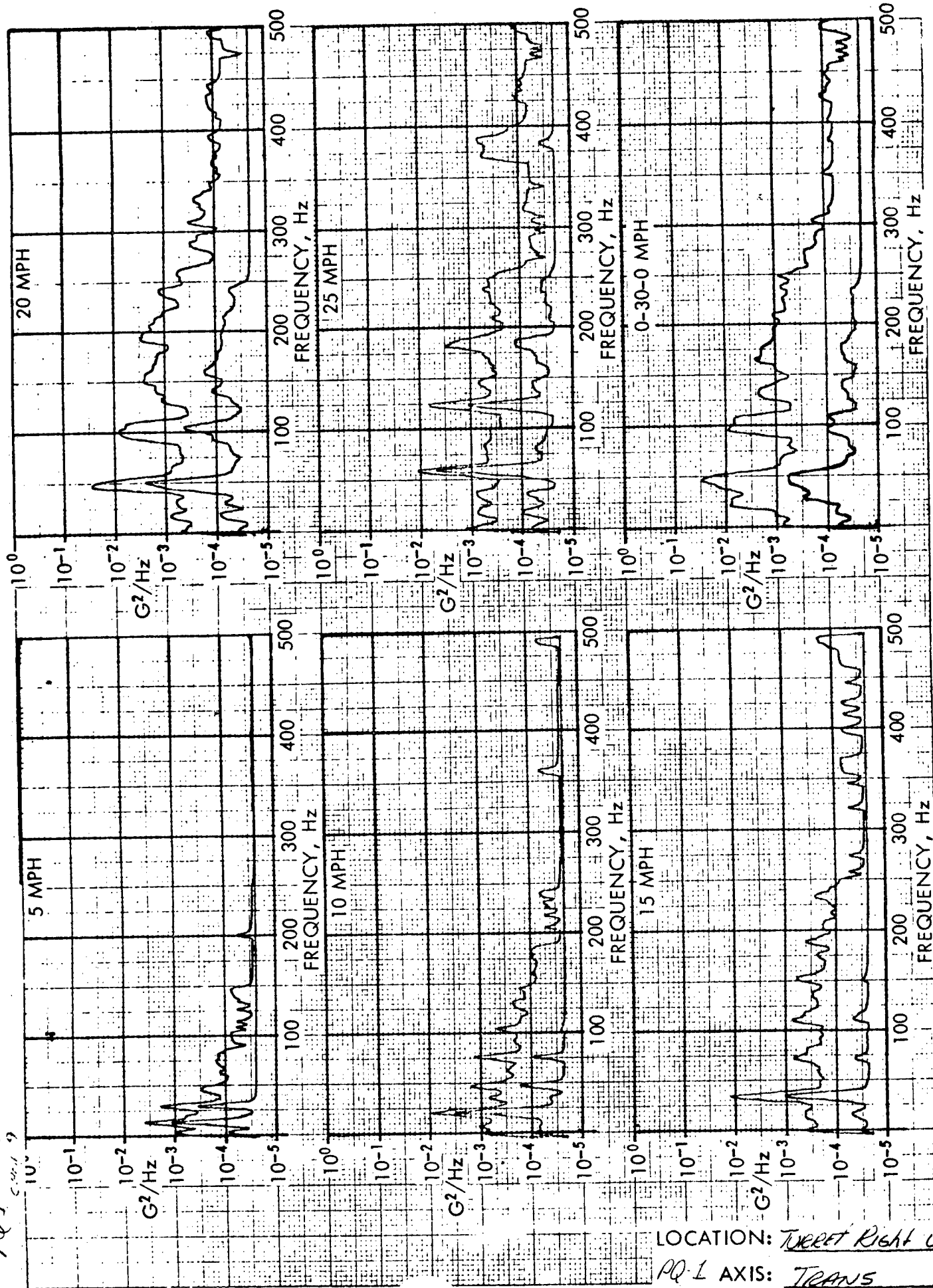
775 VIB

AQ1 Loc 4 used



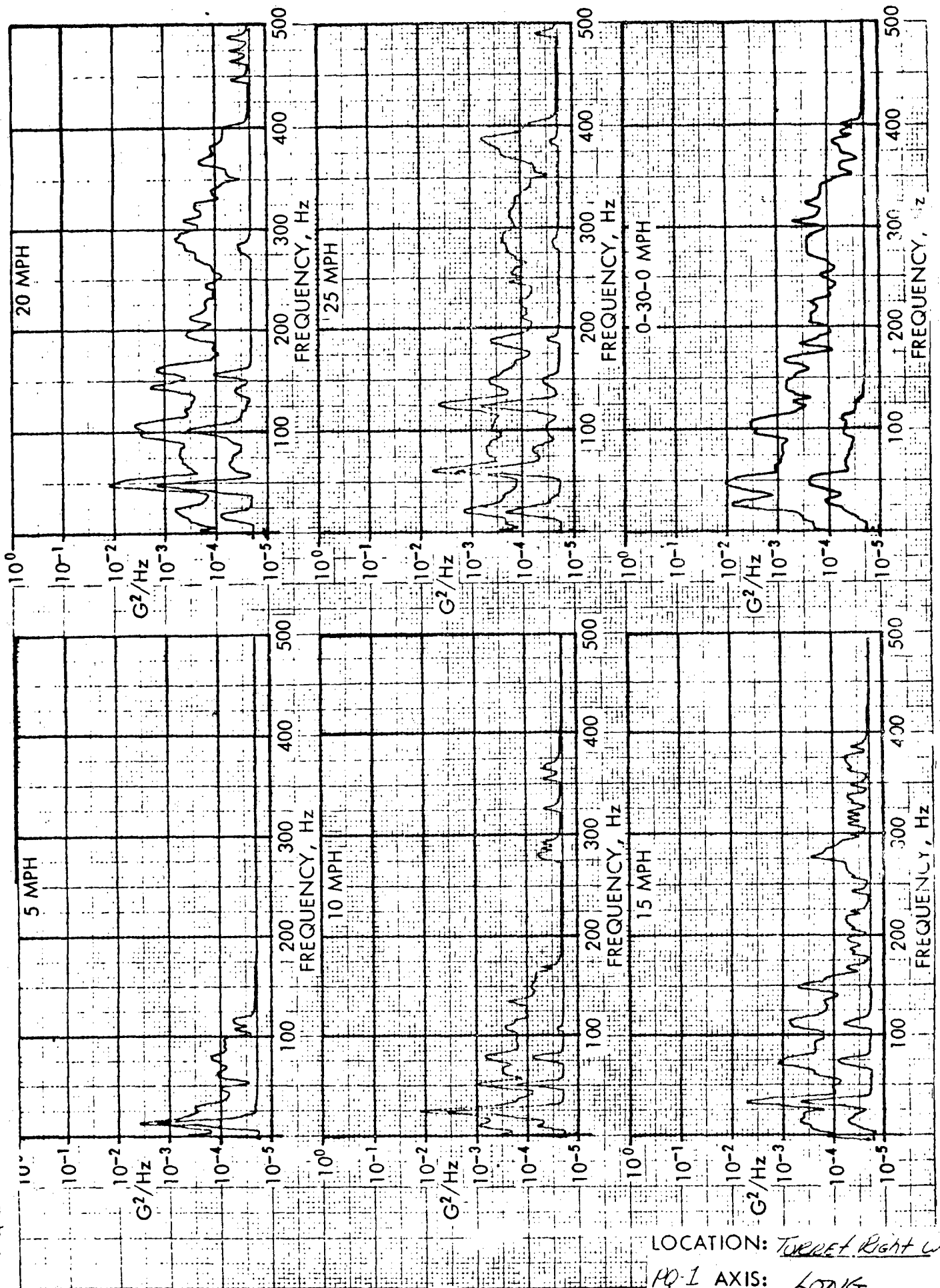
LOCATION: Turned Right with
 PQ-1 AXIS: Vert

TTS VIB
 PQ 1 Loc 4 Trans
 C-101-9



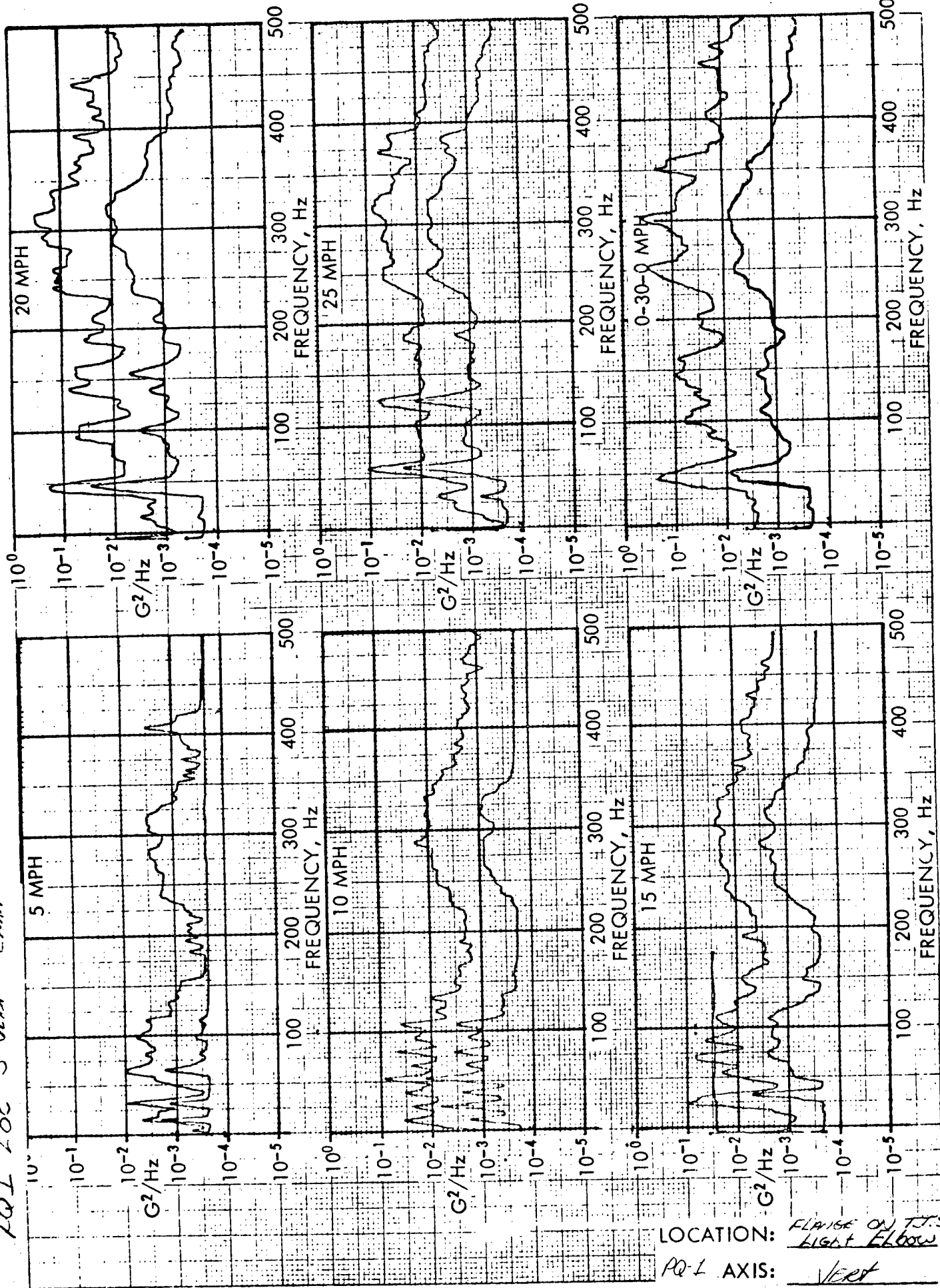
LOCATION: Turret Right Wall
 PQ-1 AXIS: TRANS

TTS Vib
 FQ-1 LOC 4 2018



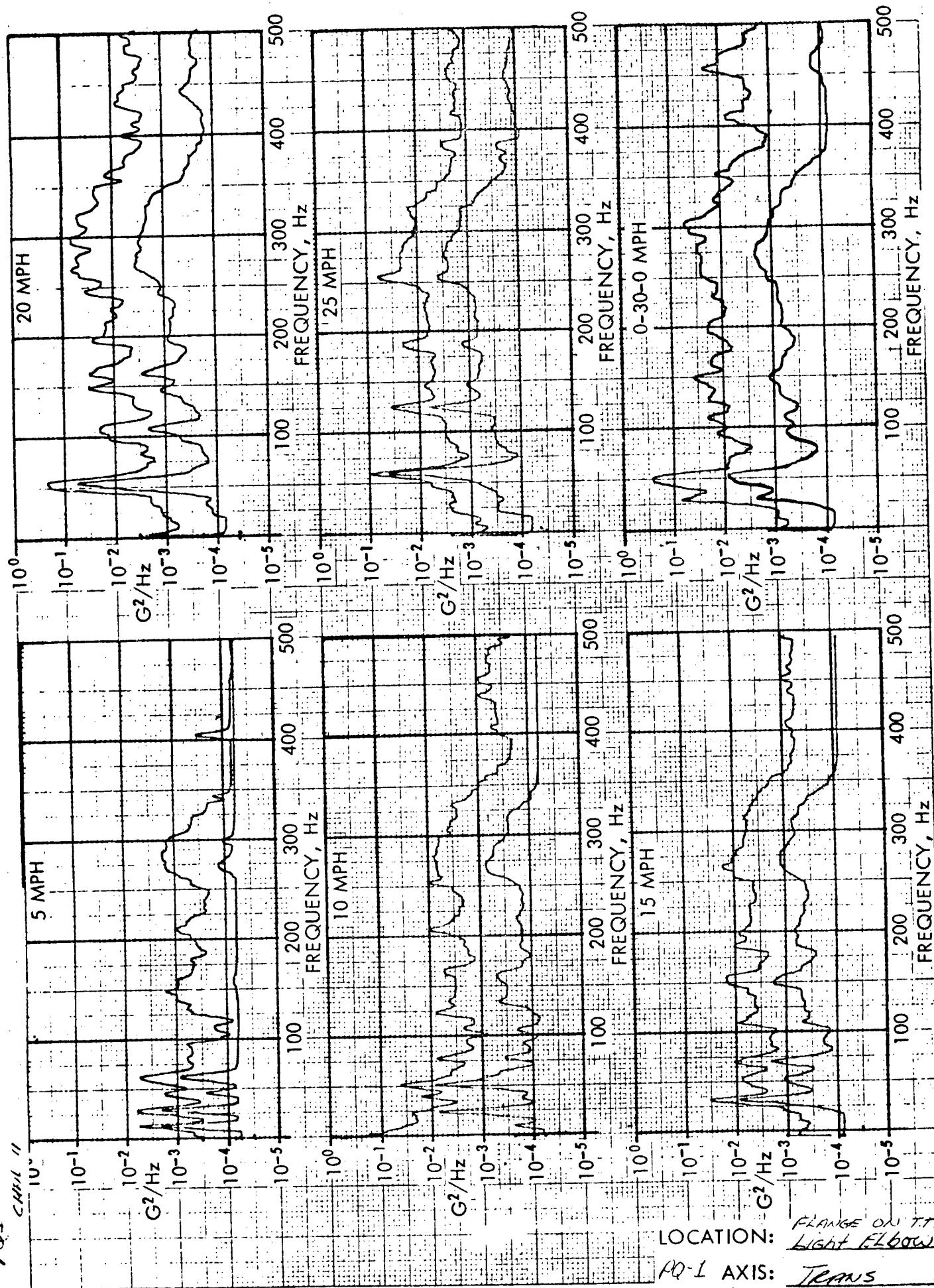
LOCATION: TURRET RIGHT WALL
 FQ-1 AXIS: LONG

TTS Vib
 PQ-1 LOC 5 vert CHAN 12



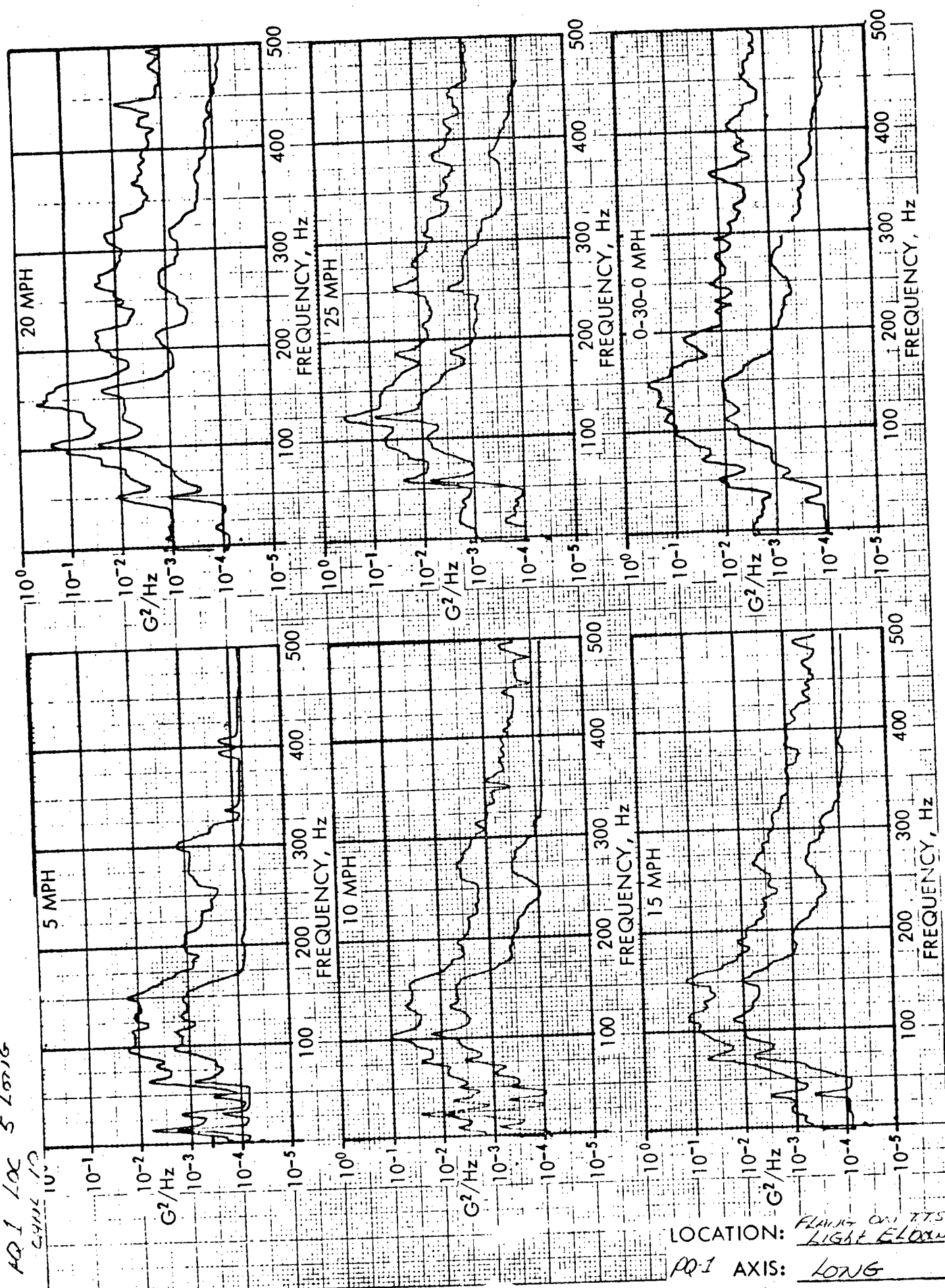
LOCATION: FLANGE ON T.T.S.
 PQ-1 AXIS: LIGHT FLOW
 VERT

775 J16
PQ1 Loc 5 Trans
CH11



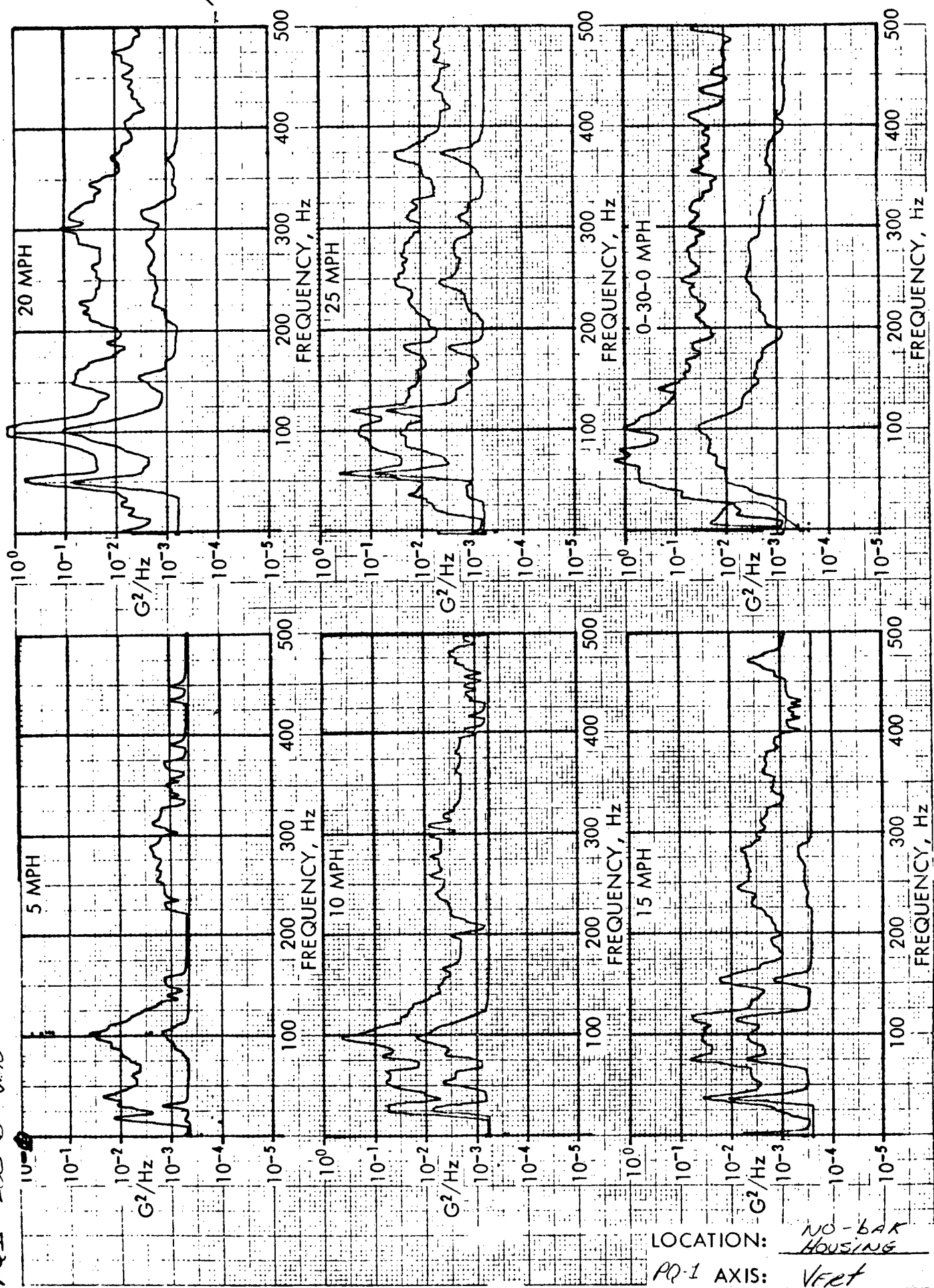
LOCATION: FLANGE ON TTS
LIGHT ELBOW
PQ-1 AXIS: TRANS

TTS V16
 AQ1 LOC
 5 LONG



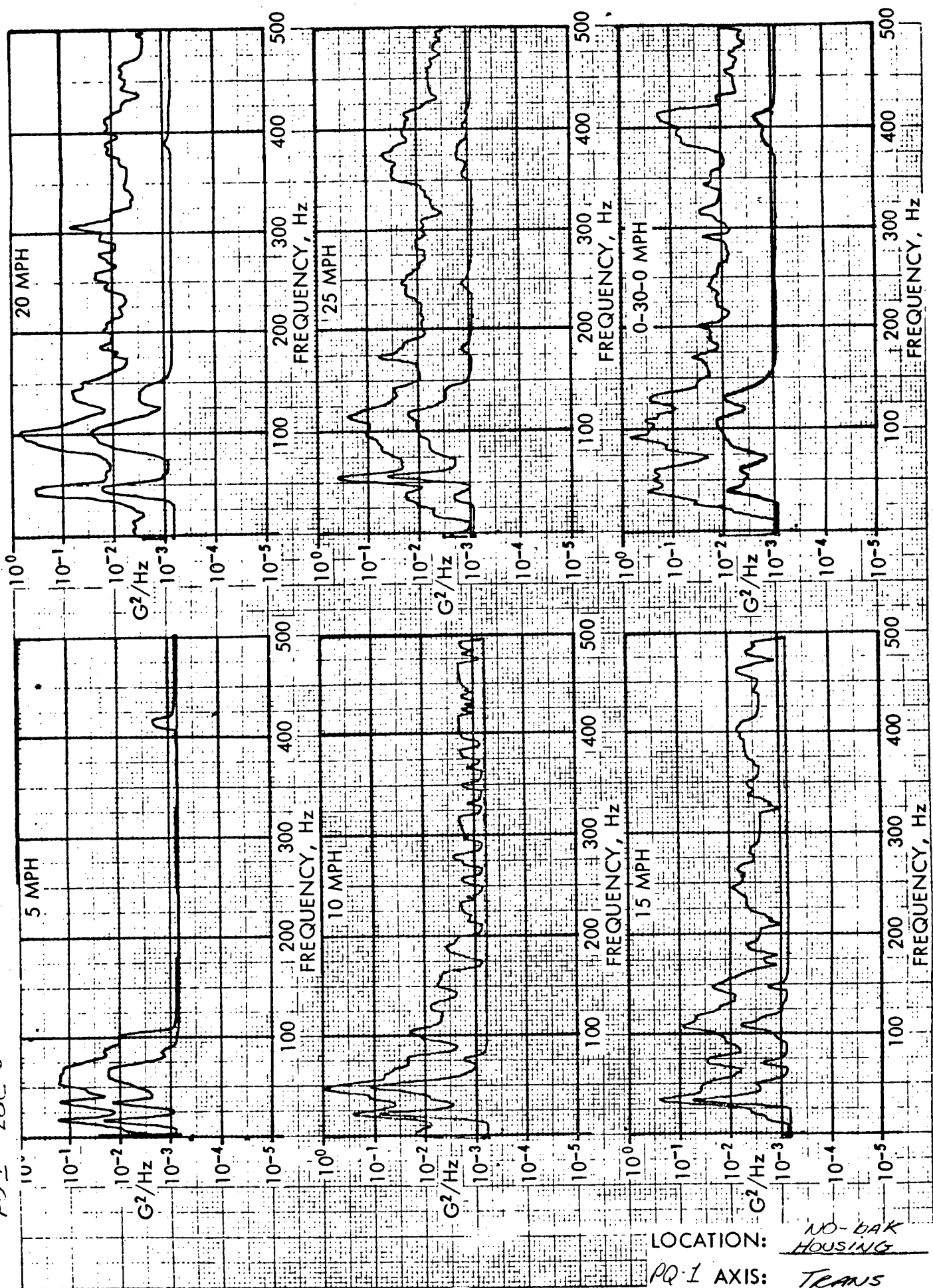
LOCATION: FLANK ON TTS
 LIGHT ELONG
 PQ-1 AXIS: LONG

PQ1 Loc 6 Vert



LOCATION: NO-6AR HOUSING
PQ-1 AXIS: VERT

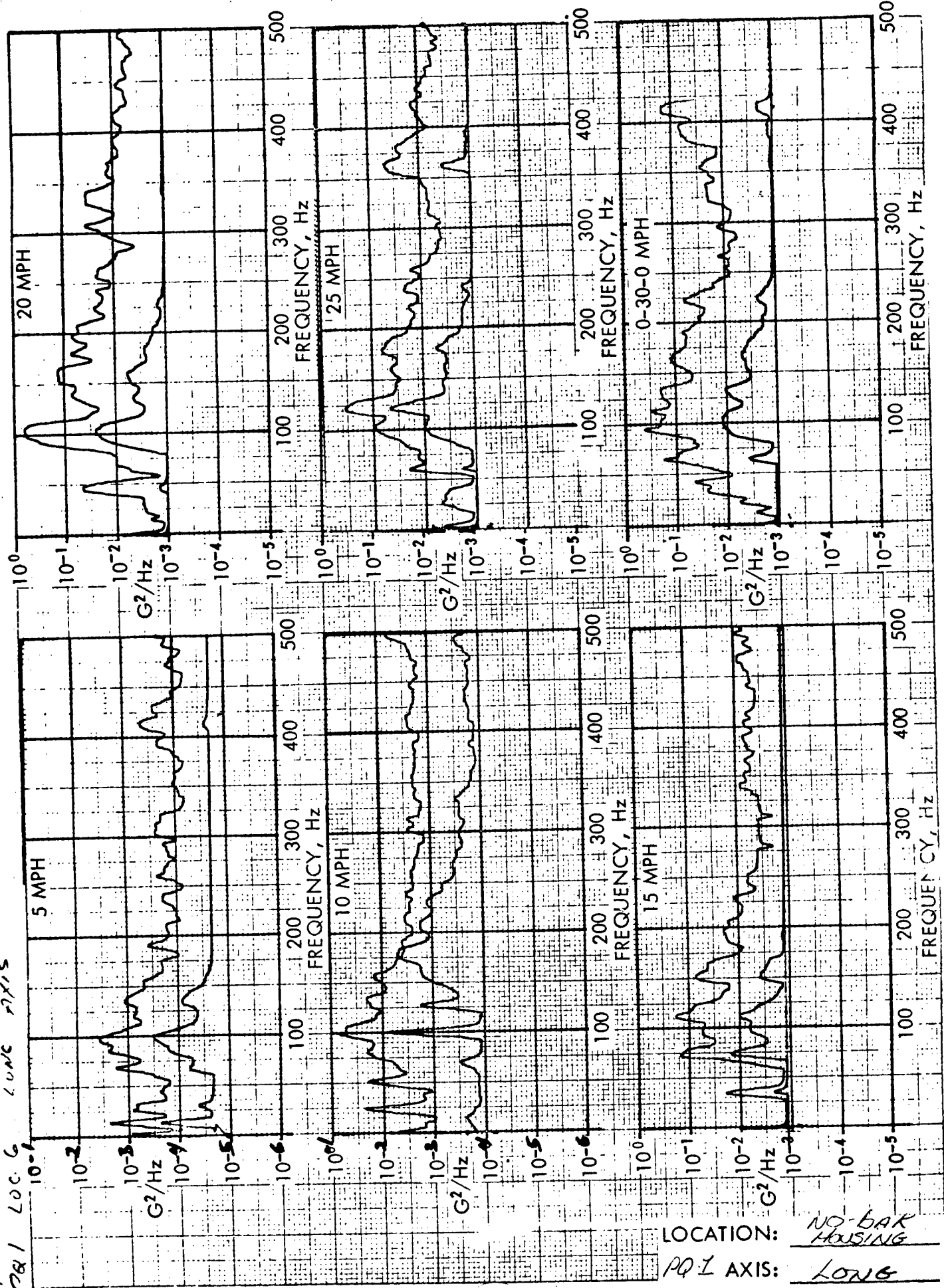
TTS Vib
PD1 LOC 6 TRANS



LOCATION: NO-DAK HOUSING
PQ-1 AXIS: TRANS

TTS VIB

P&I LOC G LONG AXIS



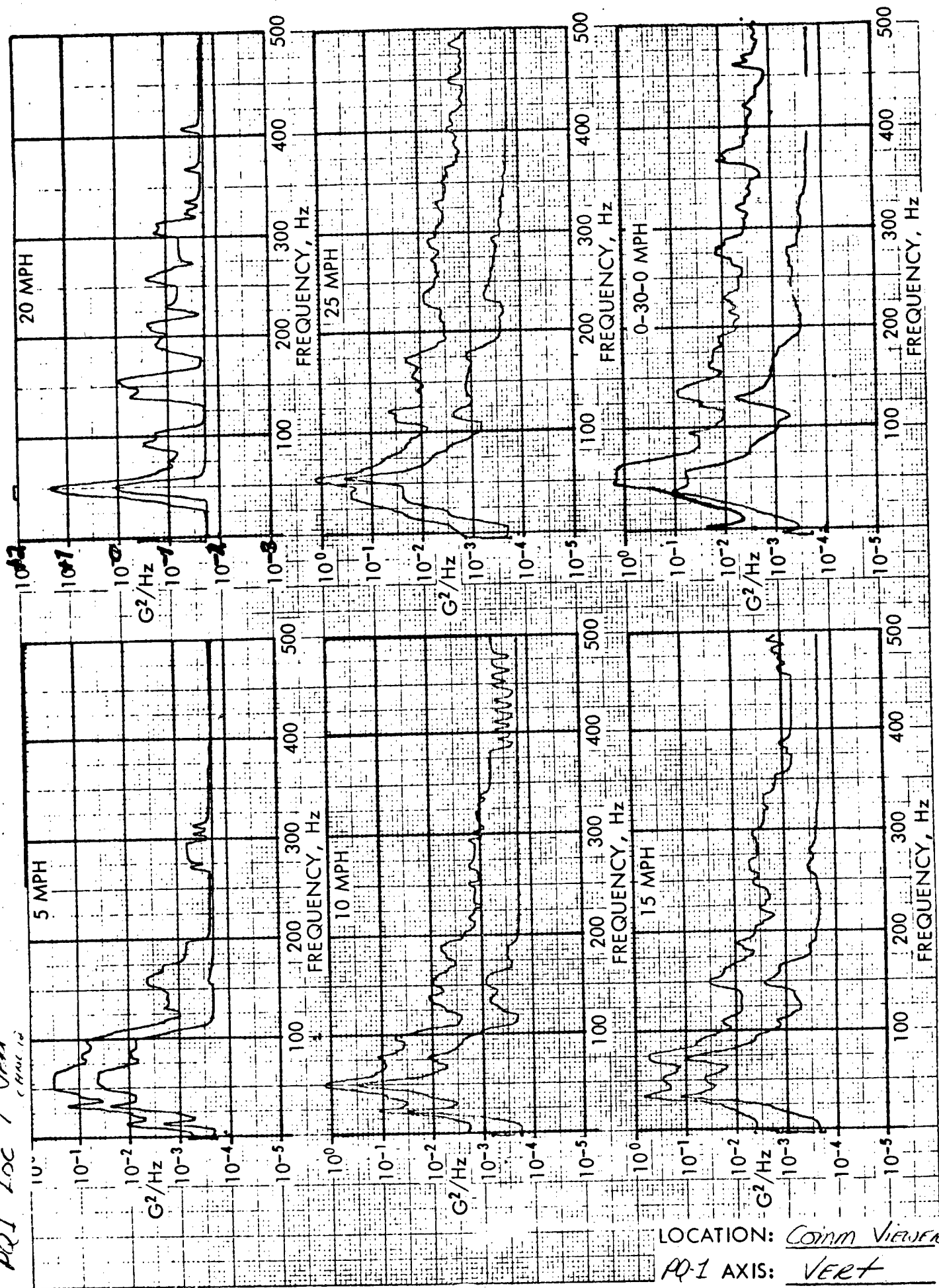
LOCATION:

NO-BAR HOUSING

PQ I AXIS:

LONG

TT3 Vib
 PQ1 Loc 7 Vert
 CHASE 12

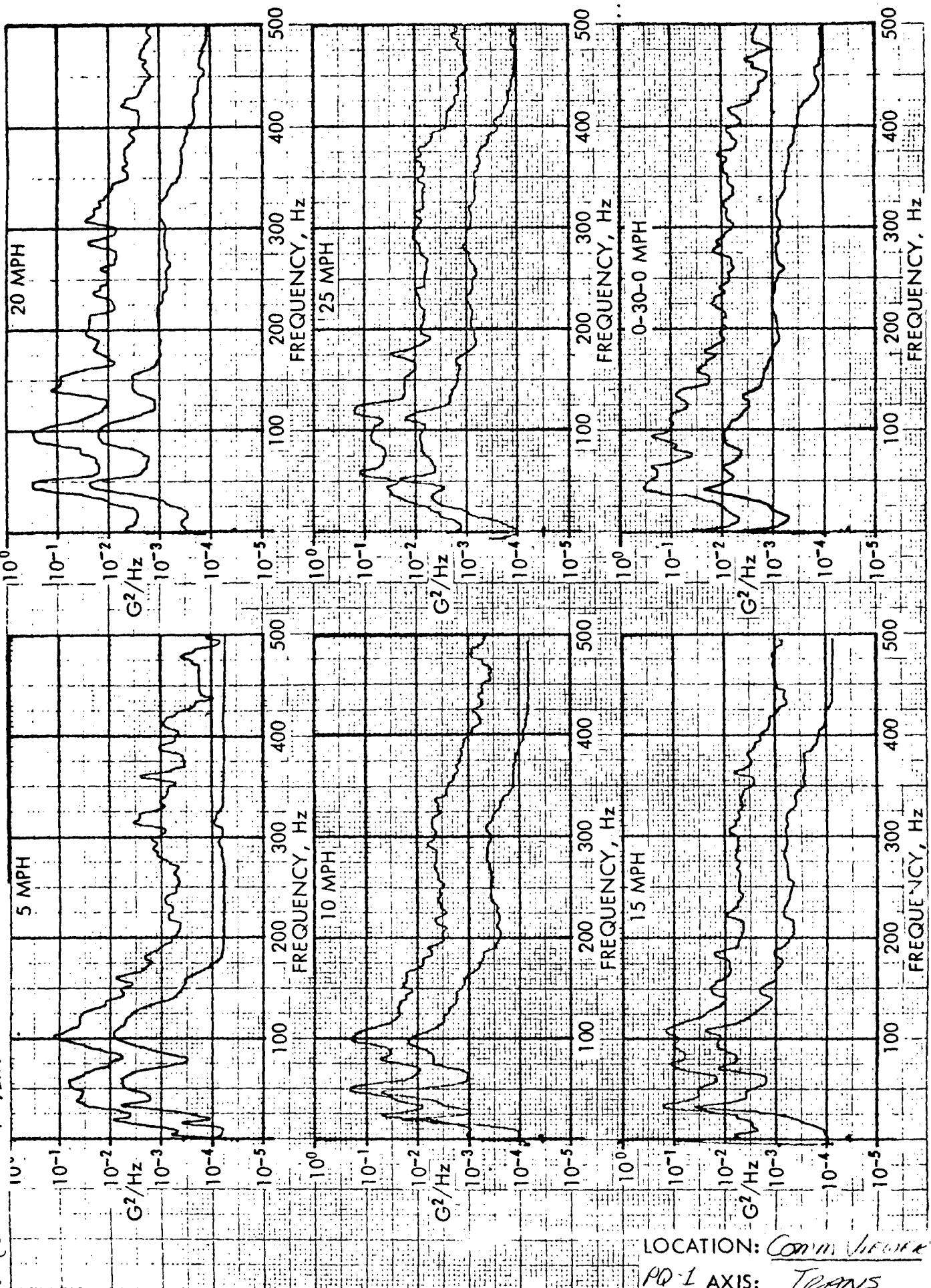


LOCATION: COMM VIEWER
 PQ-1 AXIS: VERT

TTS VIB

PQ1 LOC 7 Trans

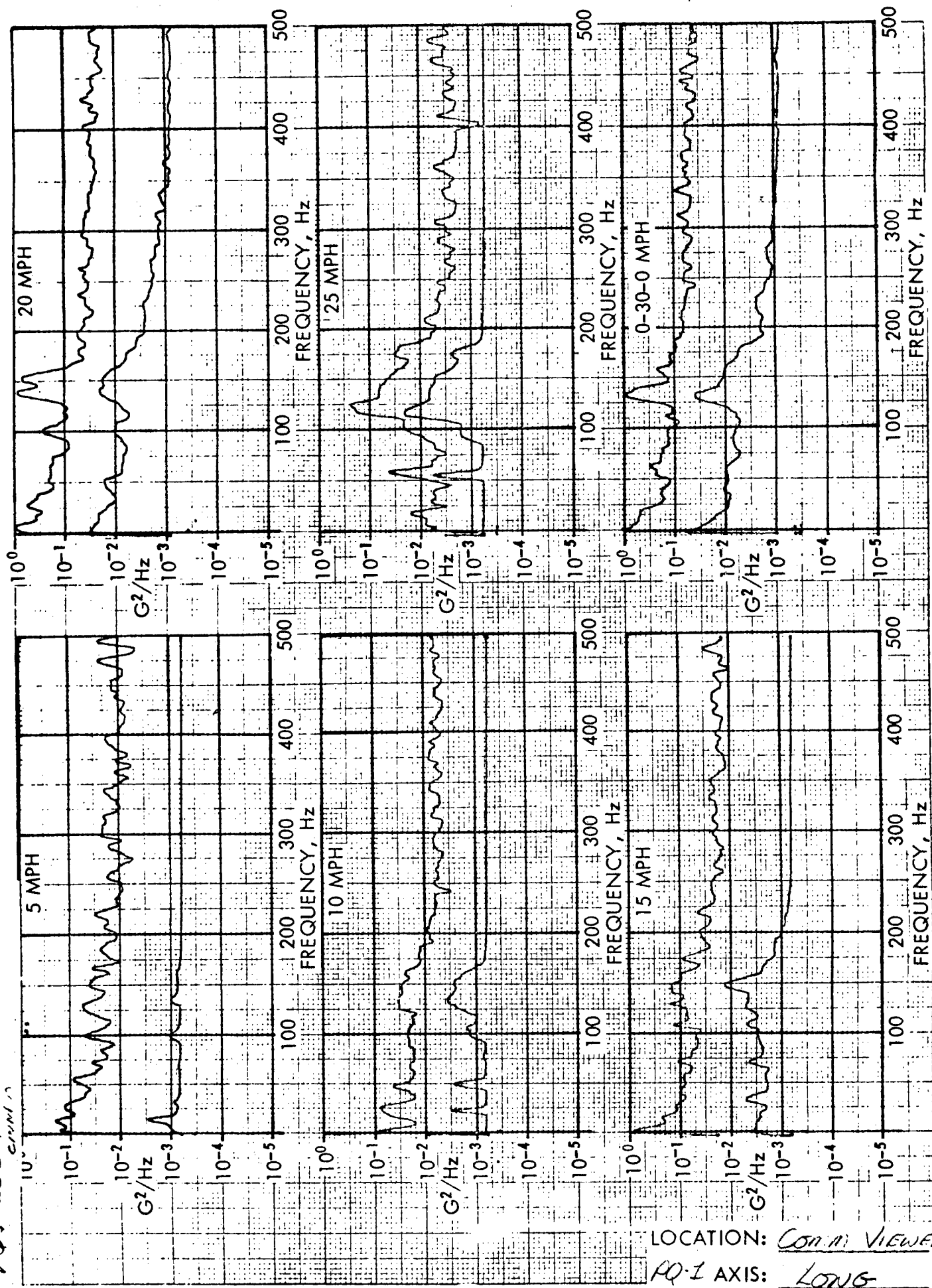
Cont'd II



LOCATION: COMM VIBRATOR
 PQ-1 AXIS: TRANS

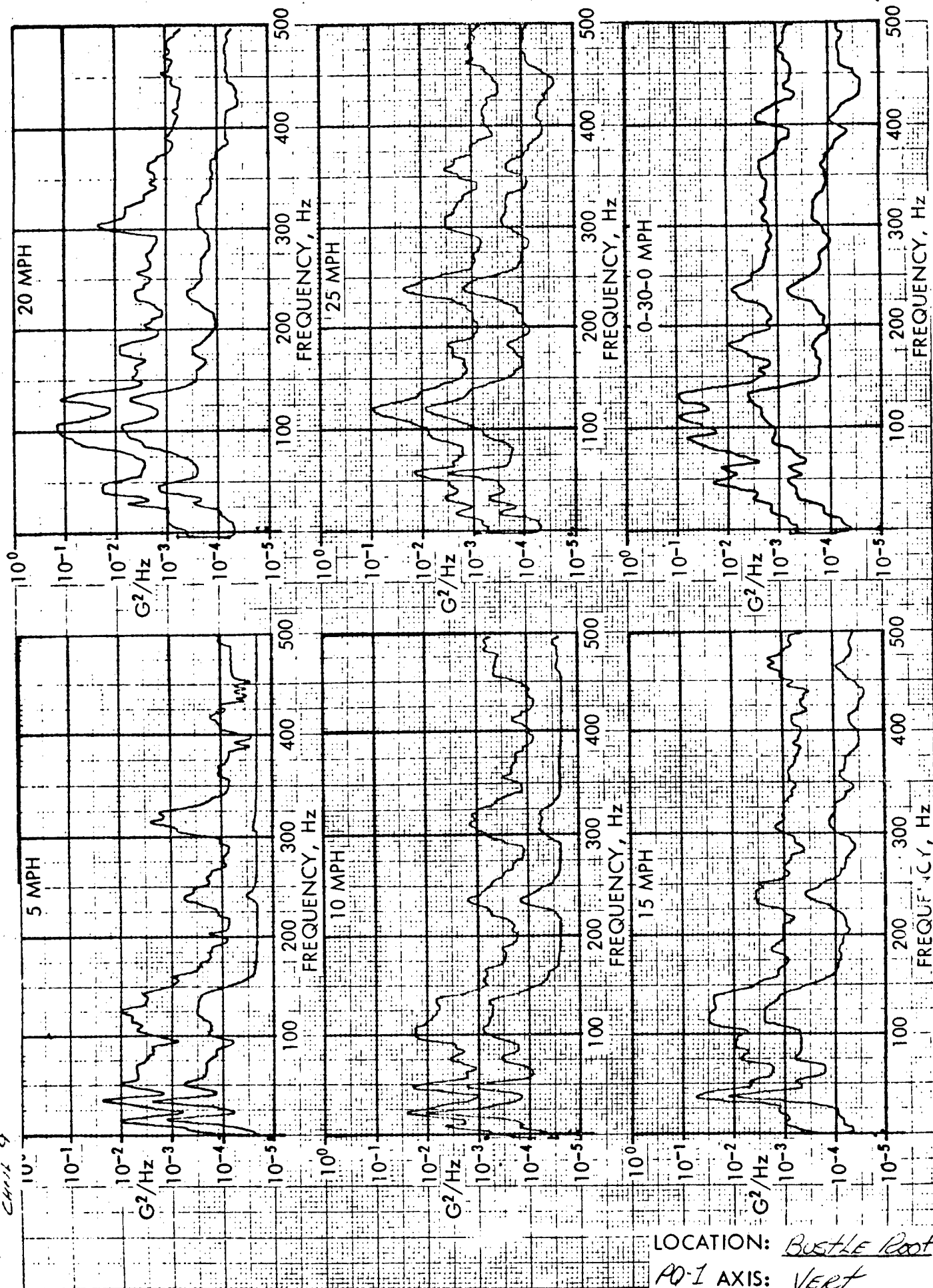
113 V13

PQ7 LOC 7 LONG



LOCATION: CON. VIEWER
PQ-1 AXIS: LONG

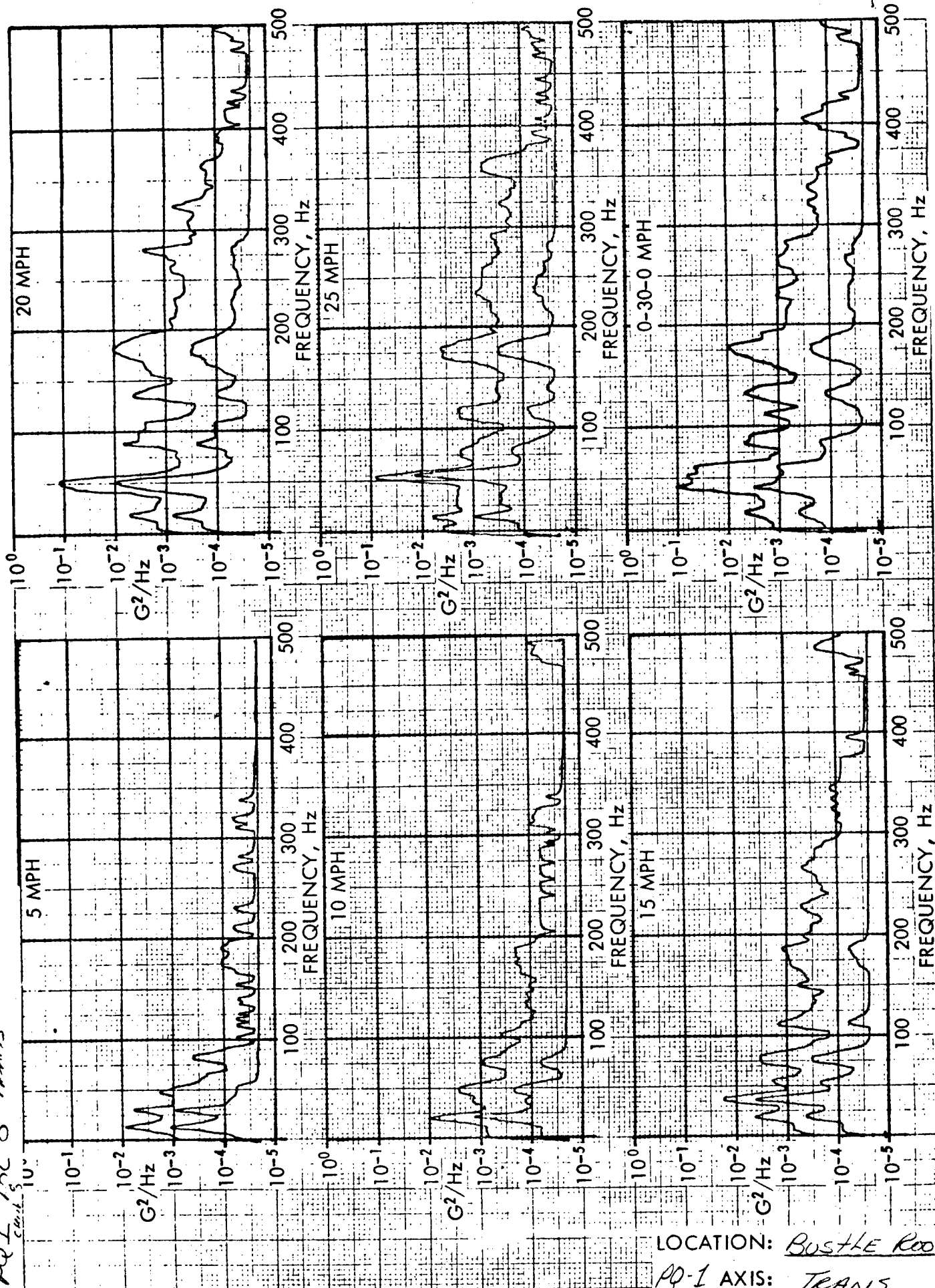
113 VIB
AQ1 Loc 8 Vert
CH 9



LOCATION: BUSTLE ROOF
PO-1 AXIS: VERT

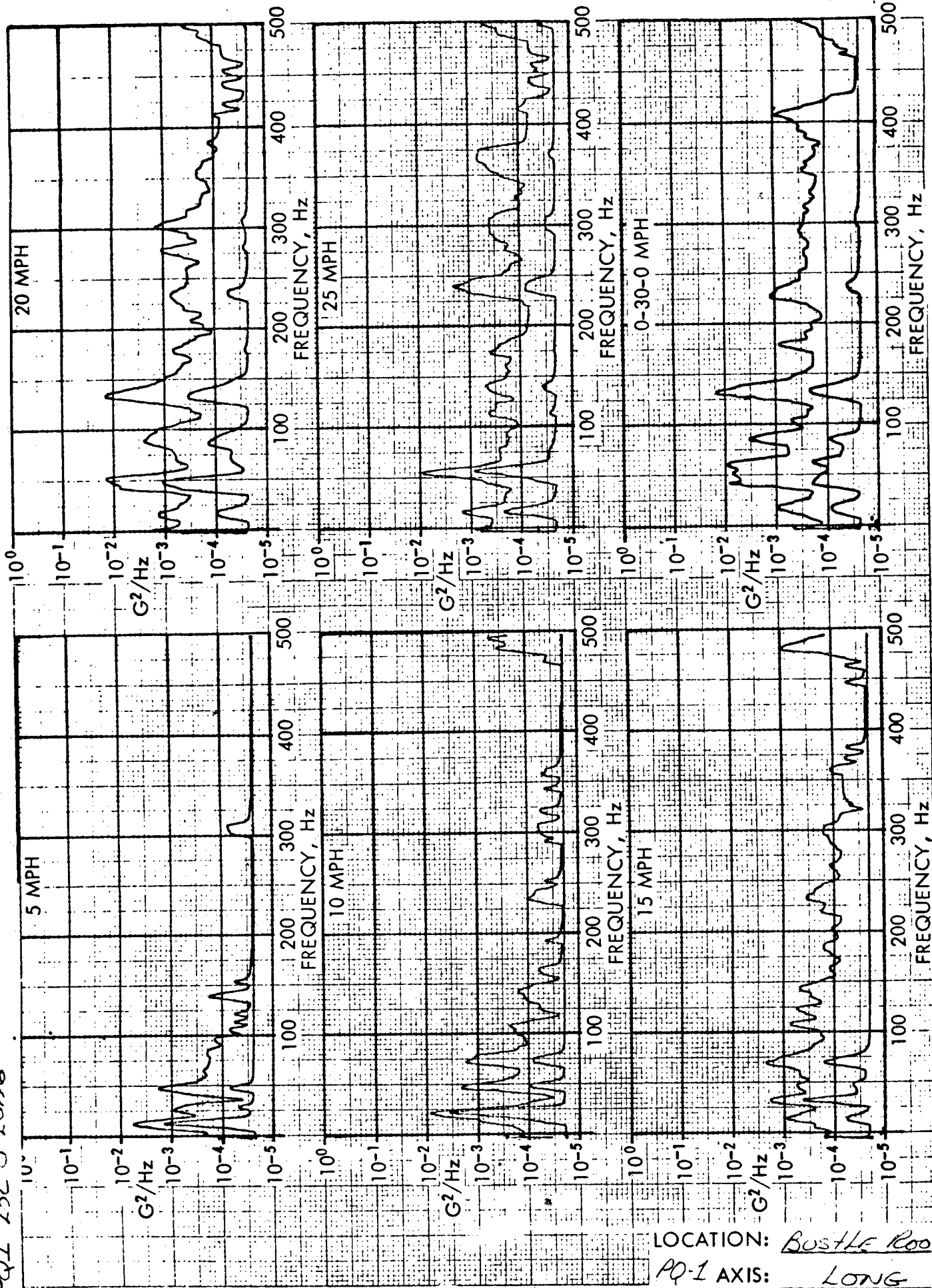
TTS VIB

PQ1 12C 8 Trans



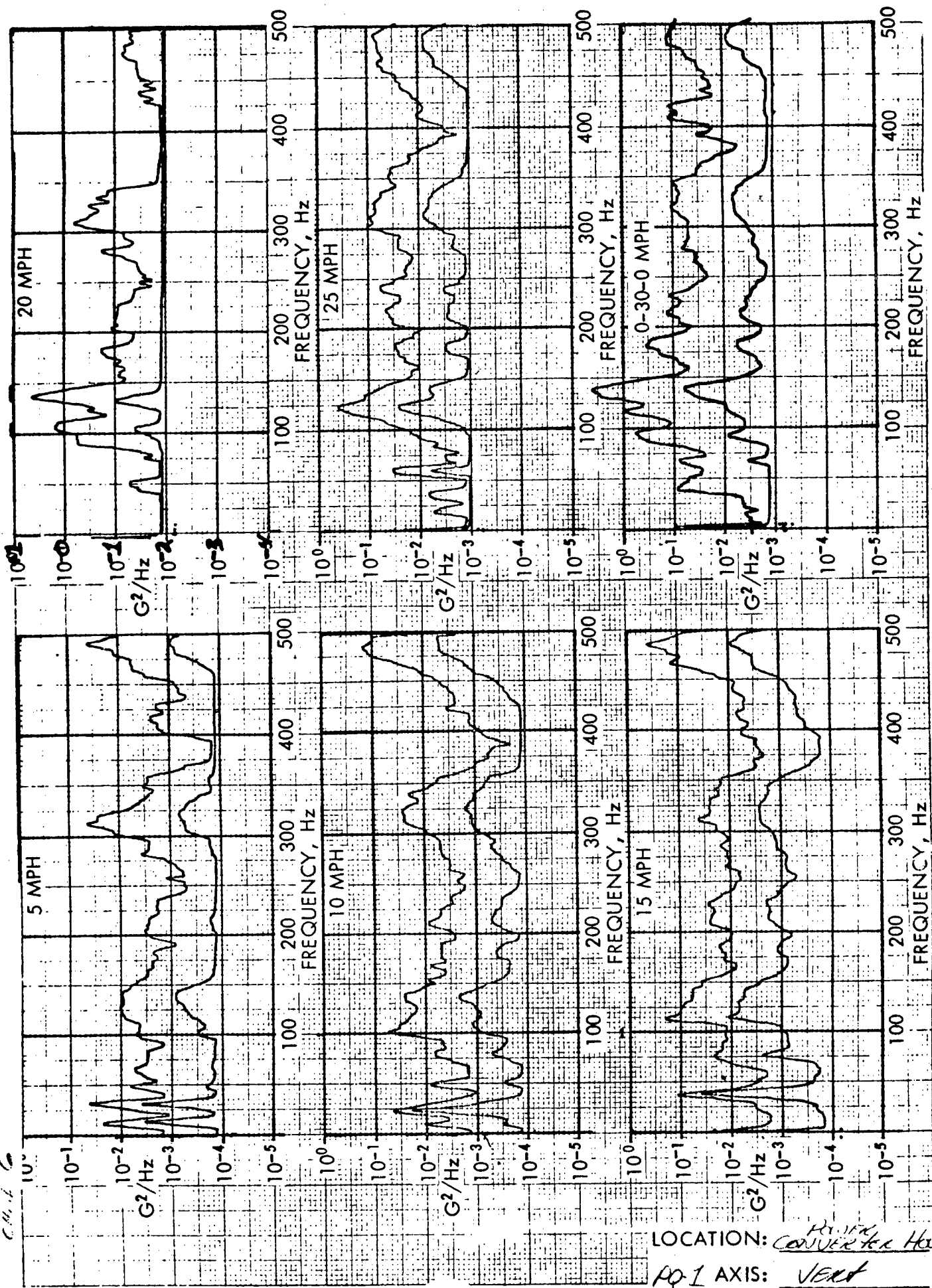
LOCATION: BUSTLE ROOF
PQ-1 AXIS: TRANS

TTS VIB
PQ1 LOC 8 L0116



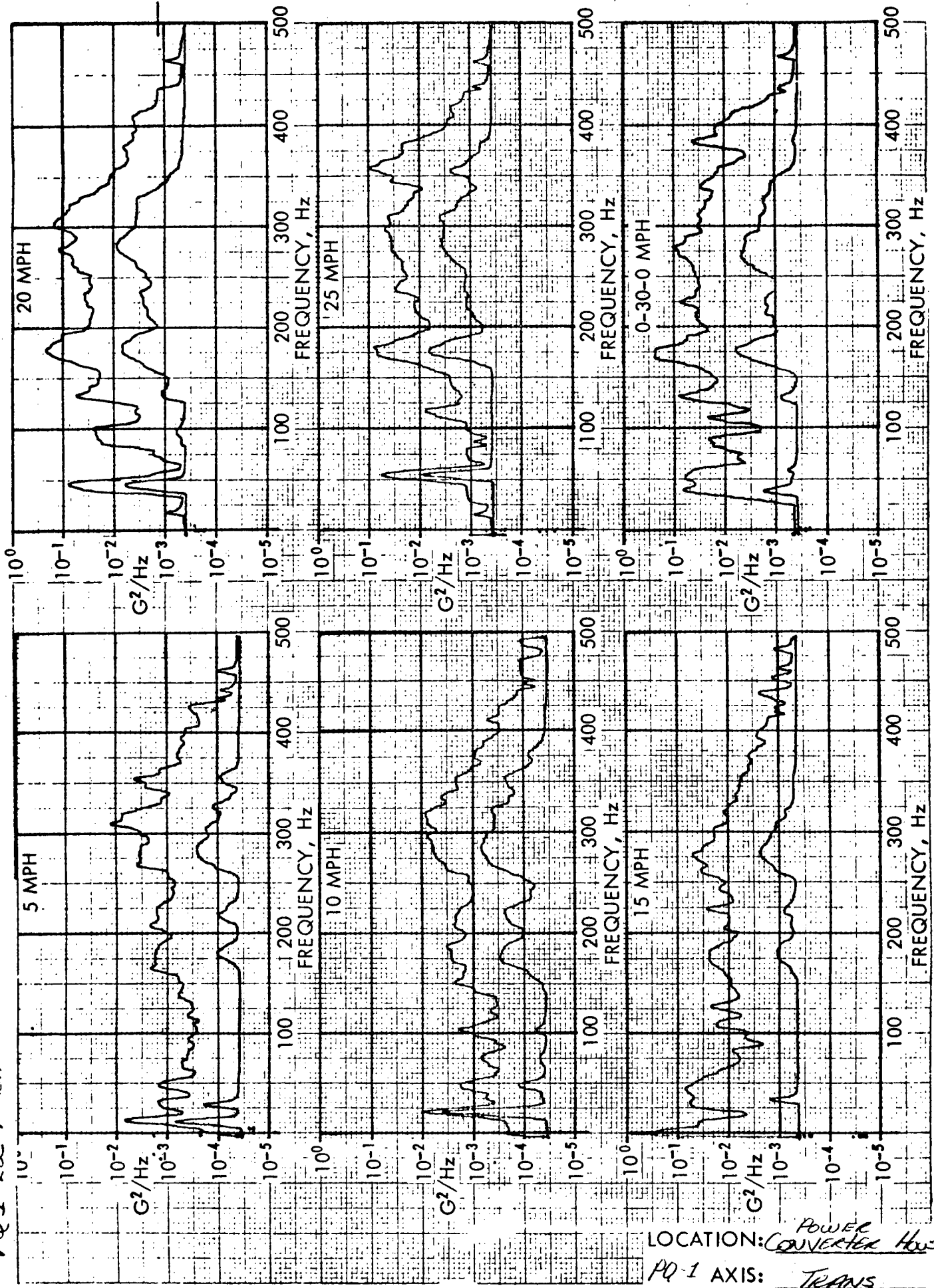
LOCATION: BUSTLE ROOF
PQ-1 AXIS: LONG

772 VIB
 PO1 LOC 9 1000
 C.M. 1 6



LOCATION: CONVERTER HOUSING
 PO-1 AXIS: VERT

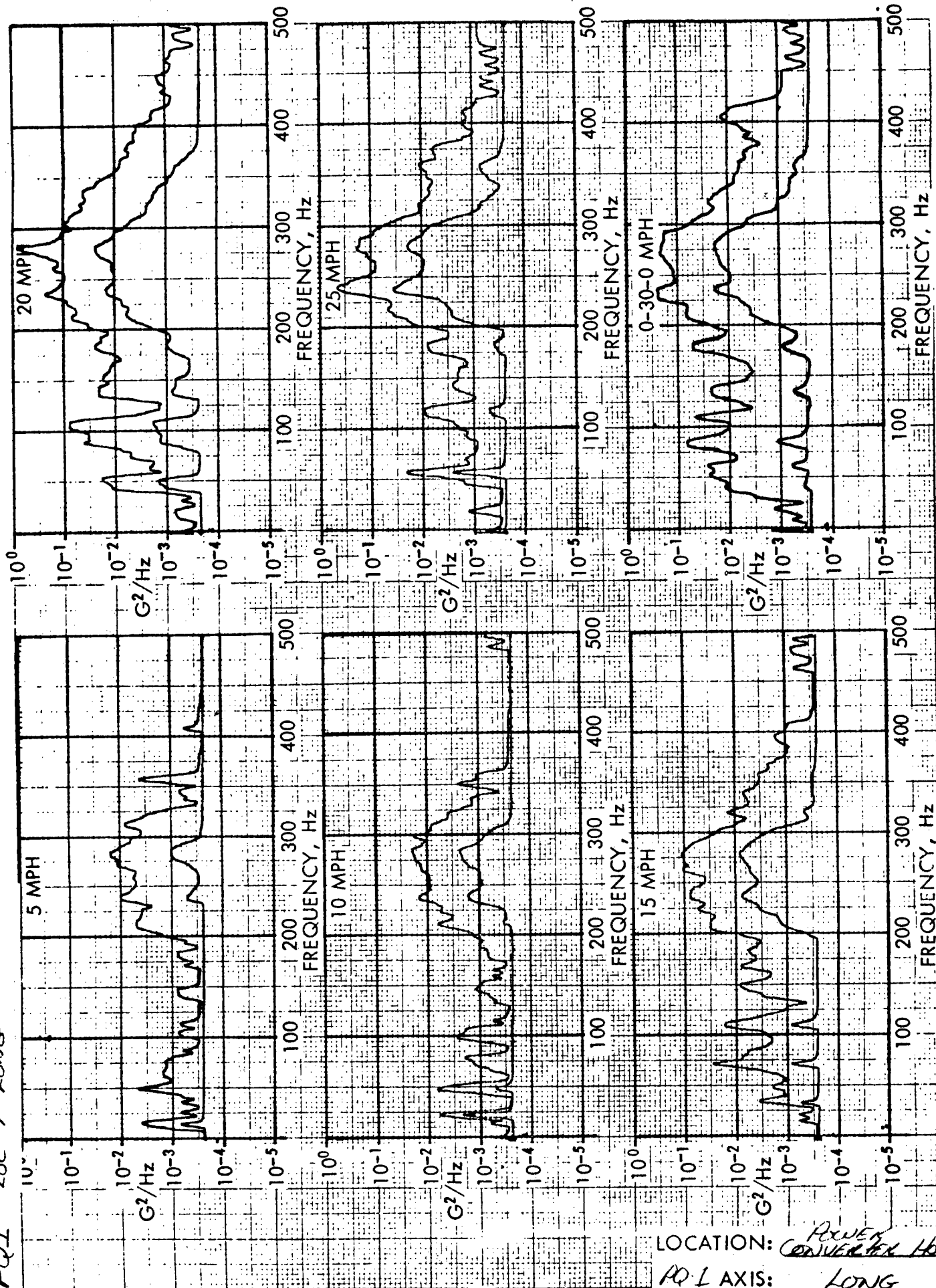
TTS V16
PQ1 Loc 9 Trans



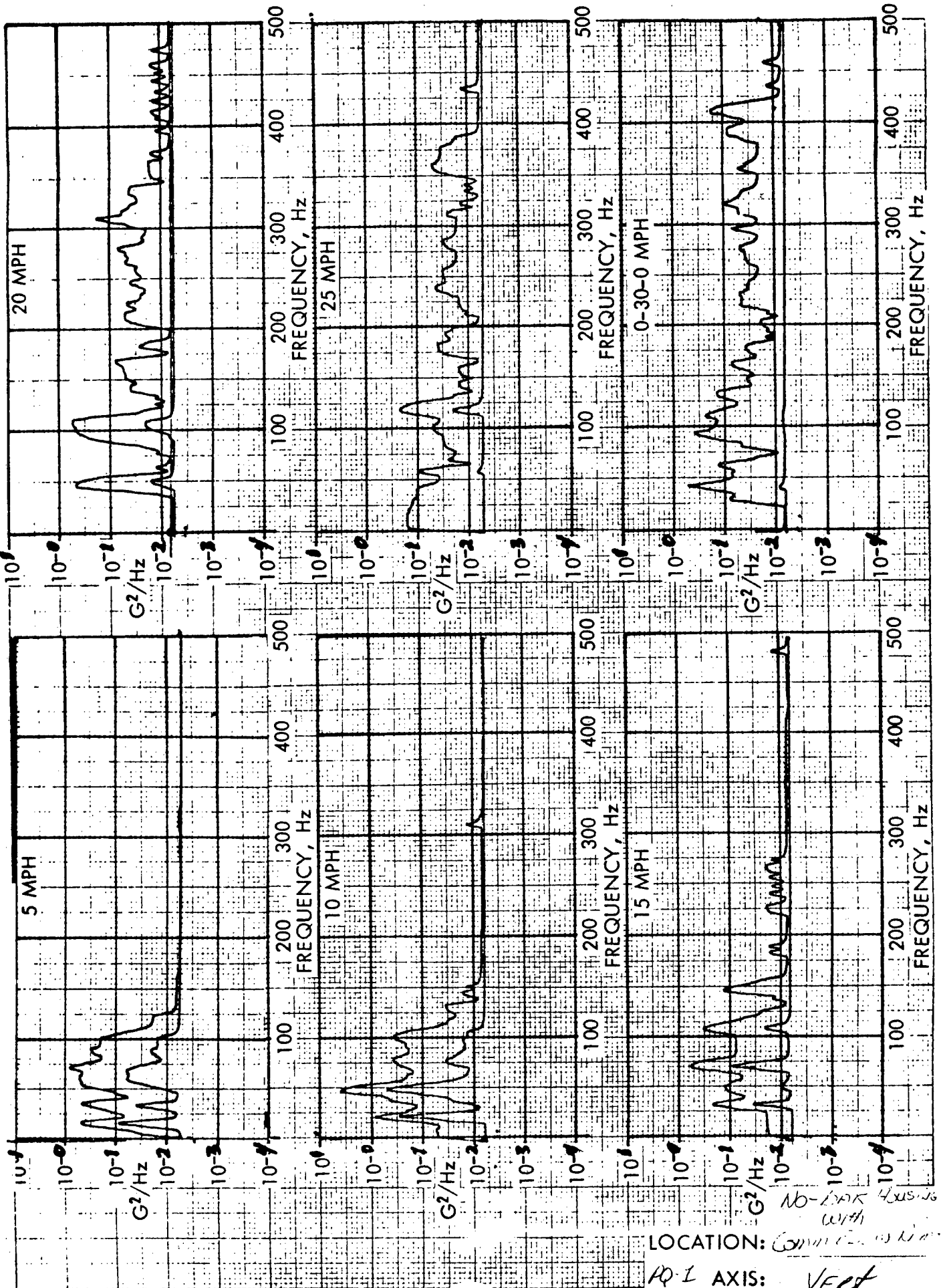
LOCATION: ^{POWER} ~~CONVERTER~~ HOUSING
PQ-1 AXIS: TRANS

775 VIB

PQ1 LOC 9 LONG

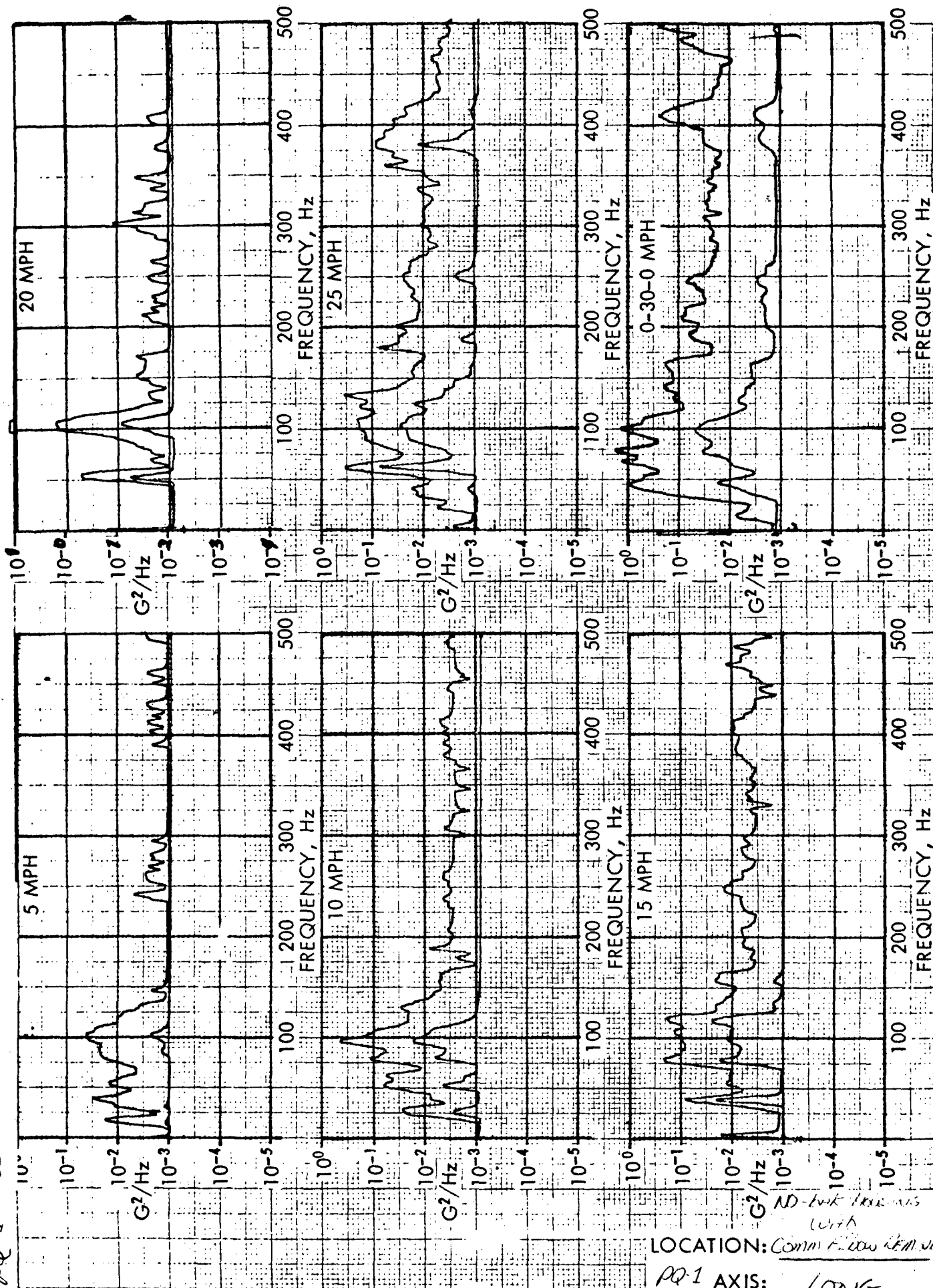


LOCATION: POWER CONVERTER HOUSING
PQ1 AXIS: LONG



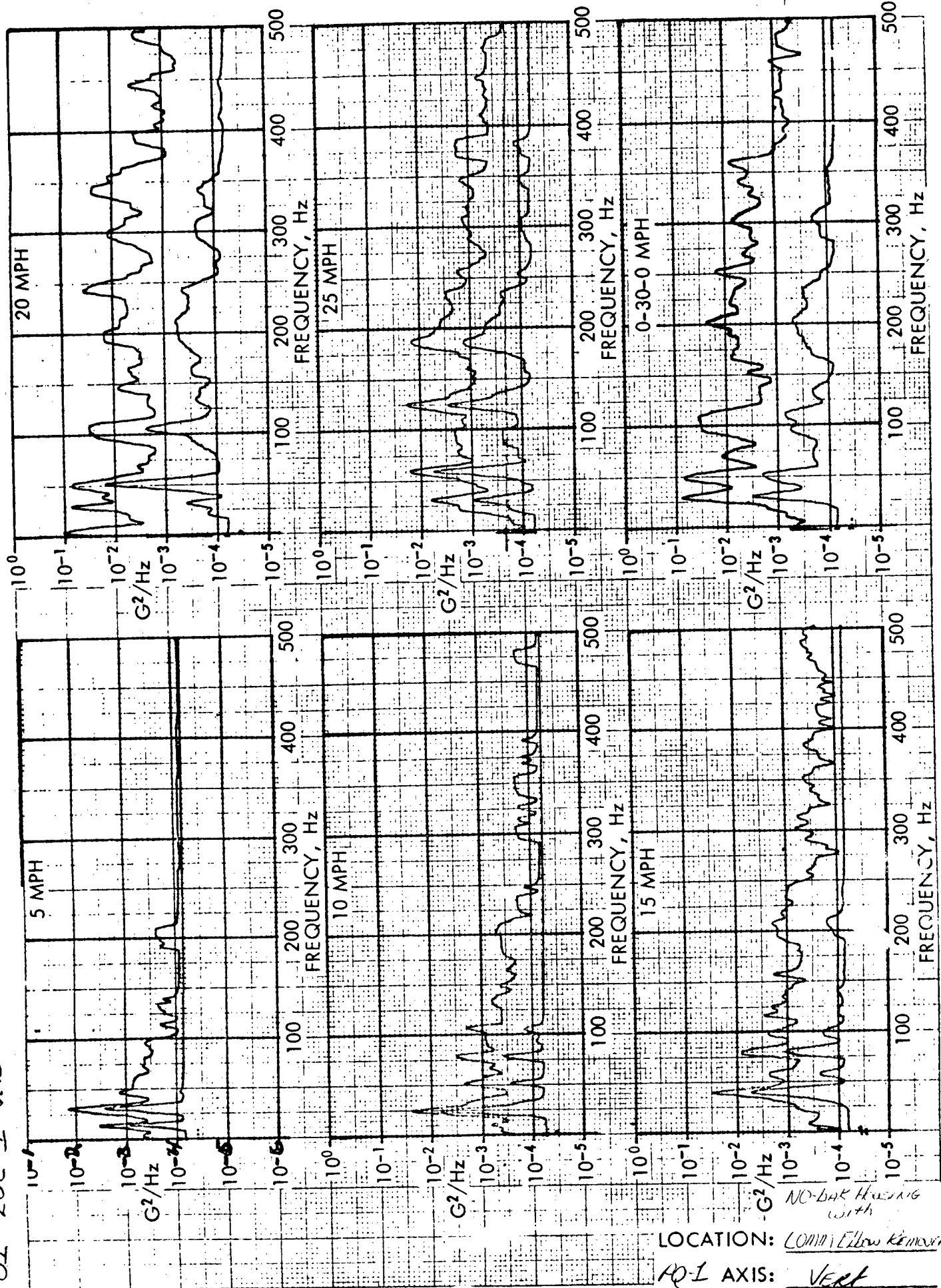
LOCATION: *COMM. 1010*
 NO-LOCK 4x5.0s
 with
 PRI AXIS: VERT

TTS VIB
 PQ 1 LOC 6 TRANS Comm Flow Remd
 101



NO-TWIST AXIS
 WITH
 LOCATION: Comm Flow Remd
 PQ-1 AXIS: LONG

TT5 VIL
PO1 LOC 1 VERT

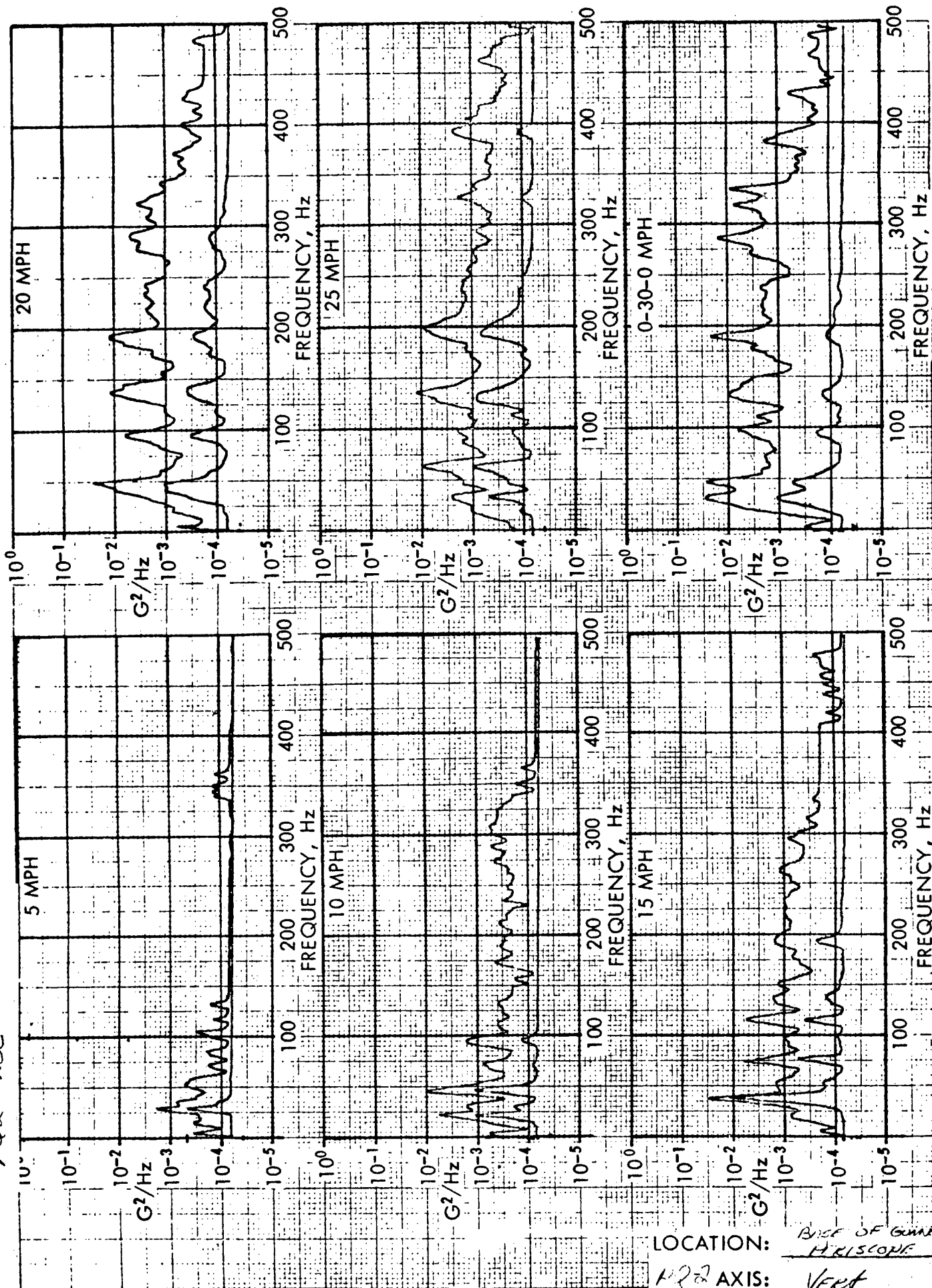


LOCATION: COMB FLOW REMOVED

PO-1 AXIS: VERT

ROAD VIBRATION P.S.D. PLOTS
ON TEST VEHICLE PQ-2
PAVED SURFACE
(CONDITION 1)

TTS Vib
AQ2 Loc 1 Vert



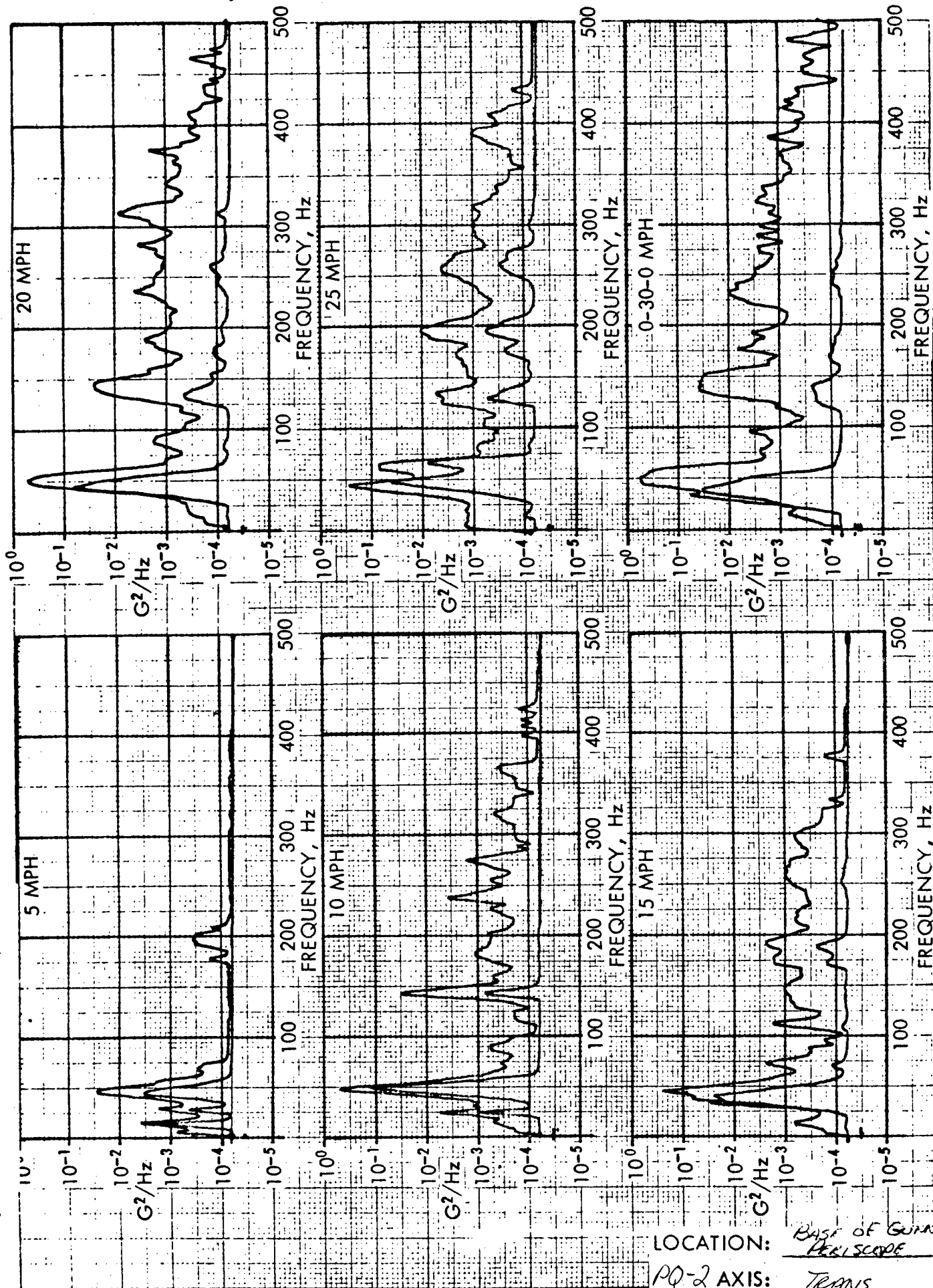
LOCATION:

AQ2 AXIS:

BRIEF OF GUNNERS
PERISCOPE

VERT

TTS V16
PQ2 LOC 1 TRANS



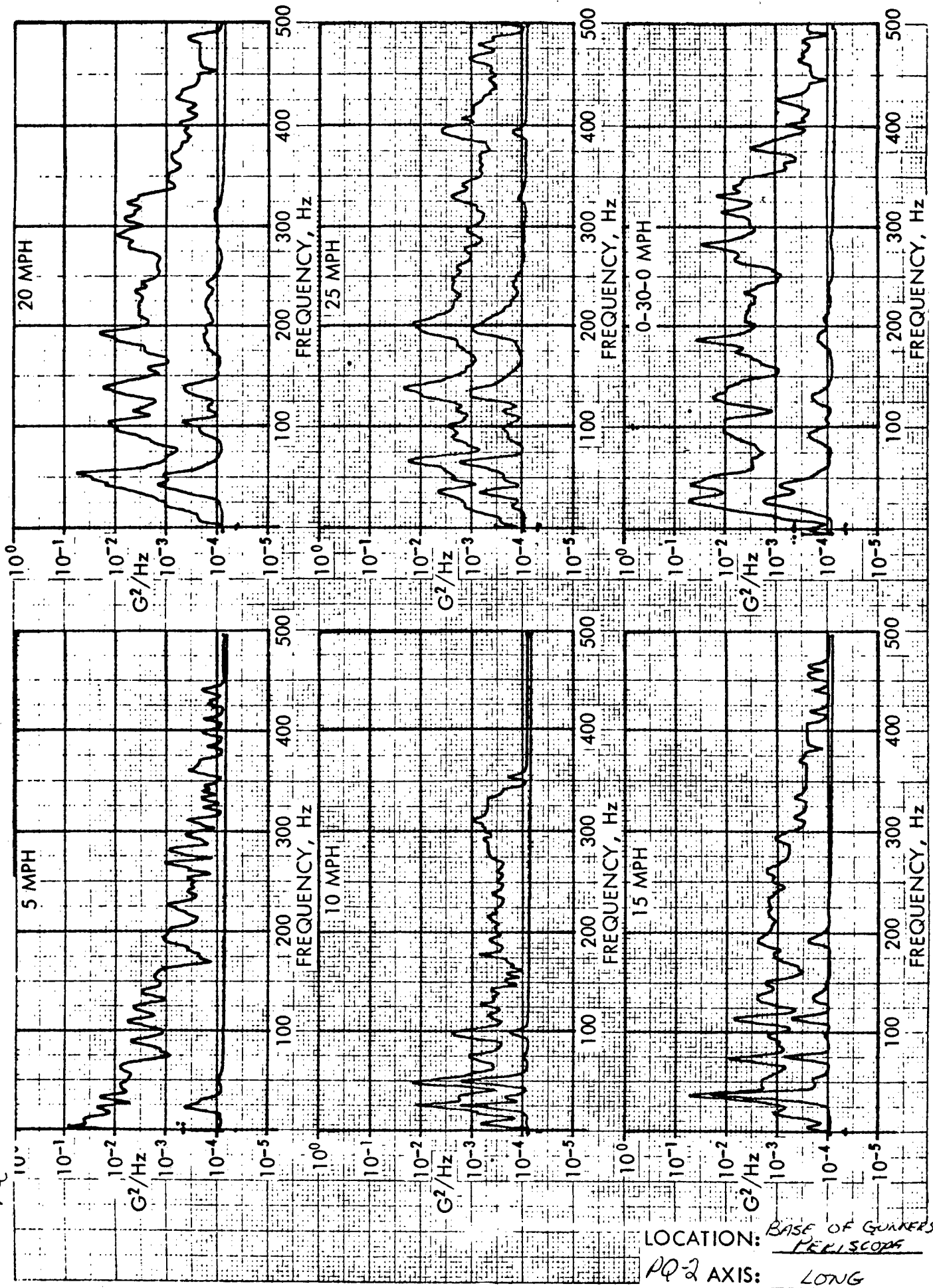
LOCATION:

PQ-2 AXIS:

BASE OF GUINER'S
PERISCOPE

TRANS

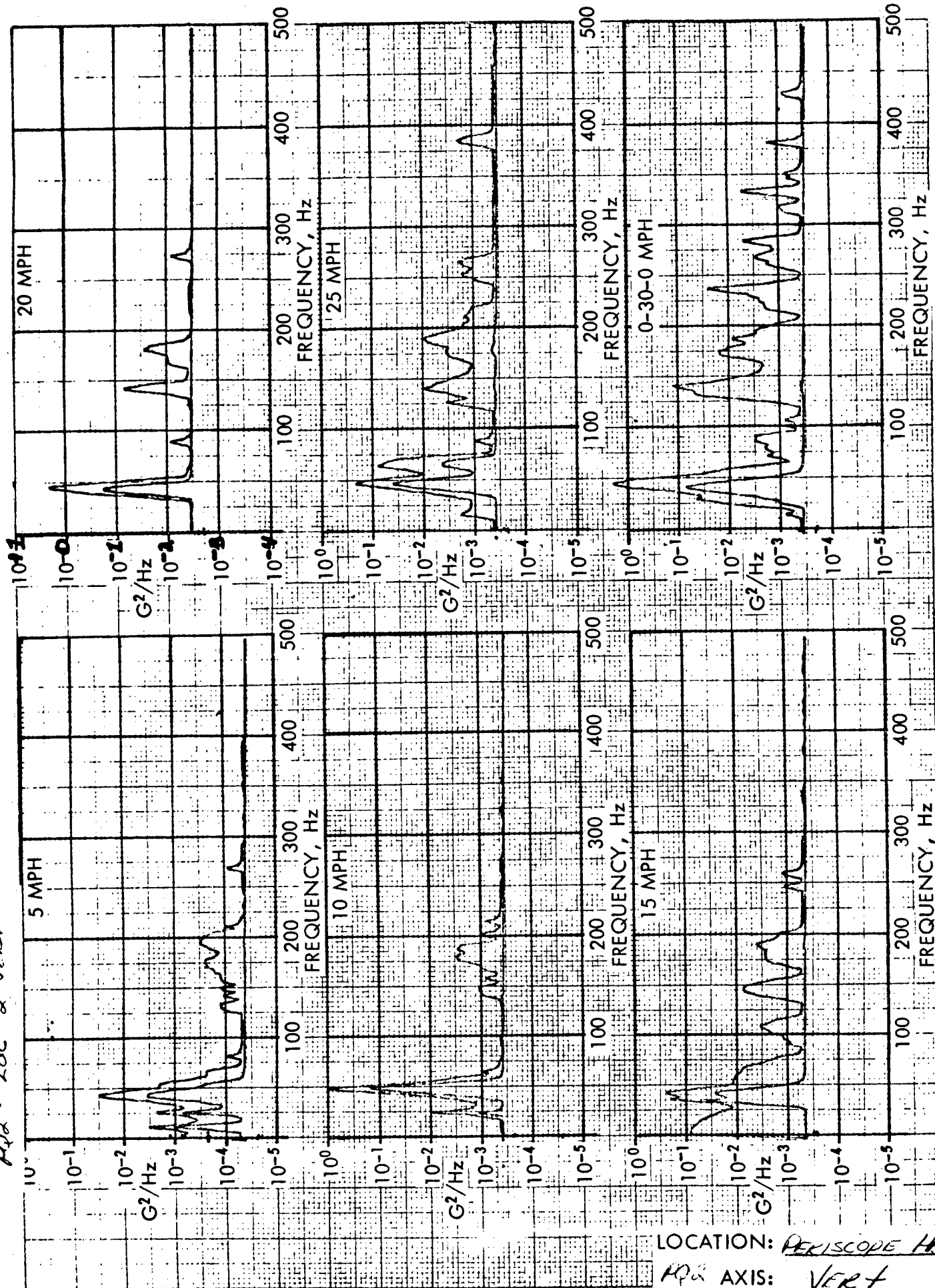
TTS Vib
 AQ-2 loc 1 Long



LOCATION: BASE OF GUINERS PERISCOPE
 AQ-2 AXIS: LONG

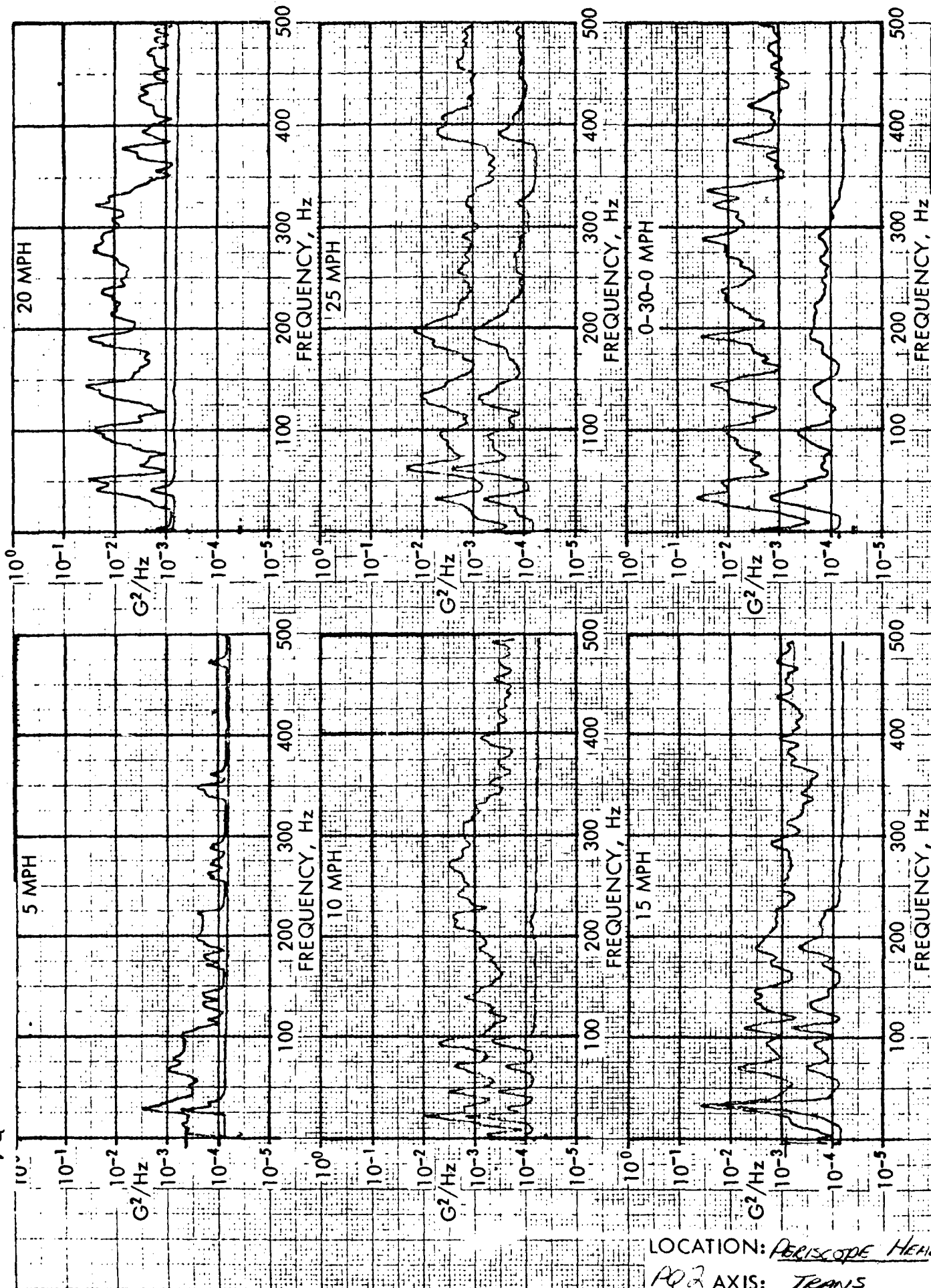
TTS Vib

PP2 - LOC 2 VERT



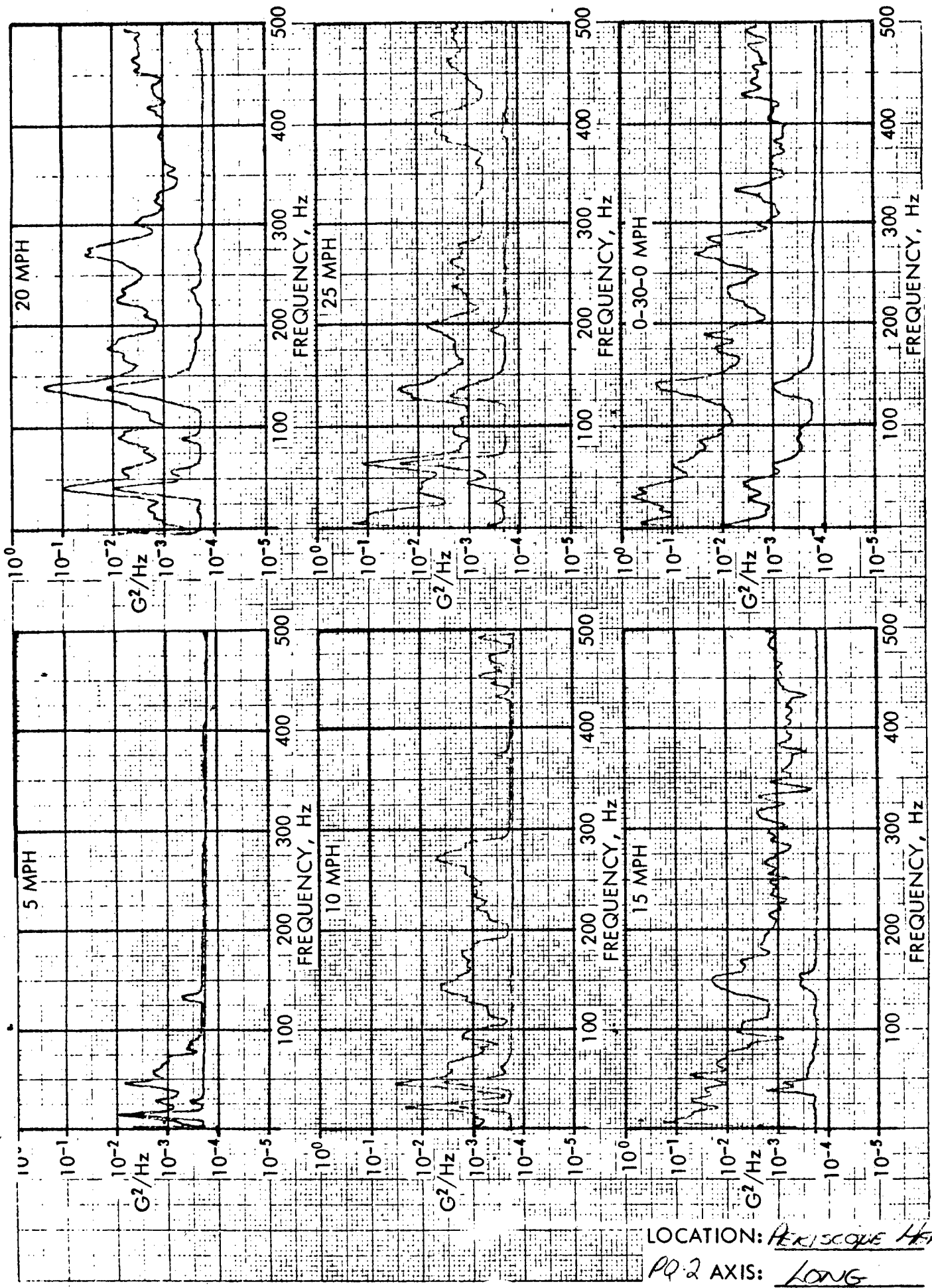
LOCATION: PERISCOPE HEAD
PP2 AXIS: VERT

TTSVib
 PQ2 Loc 2 Trans



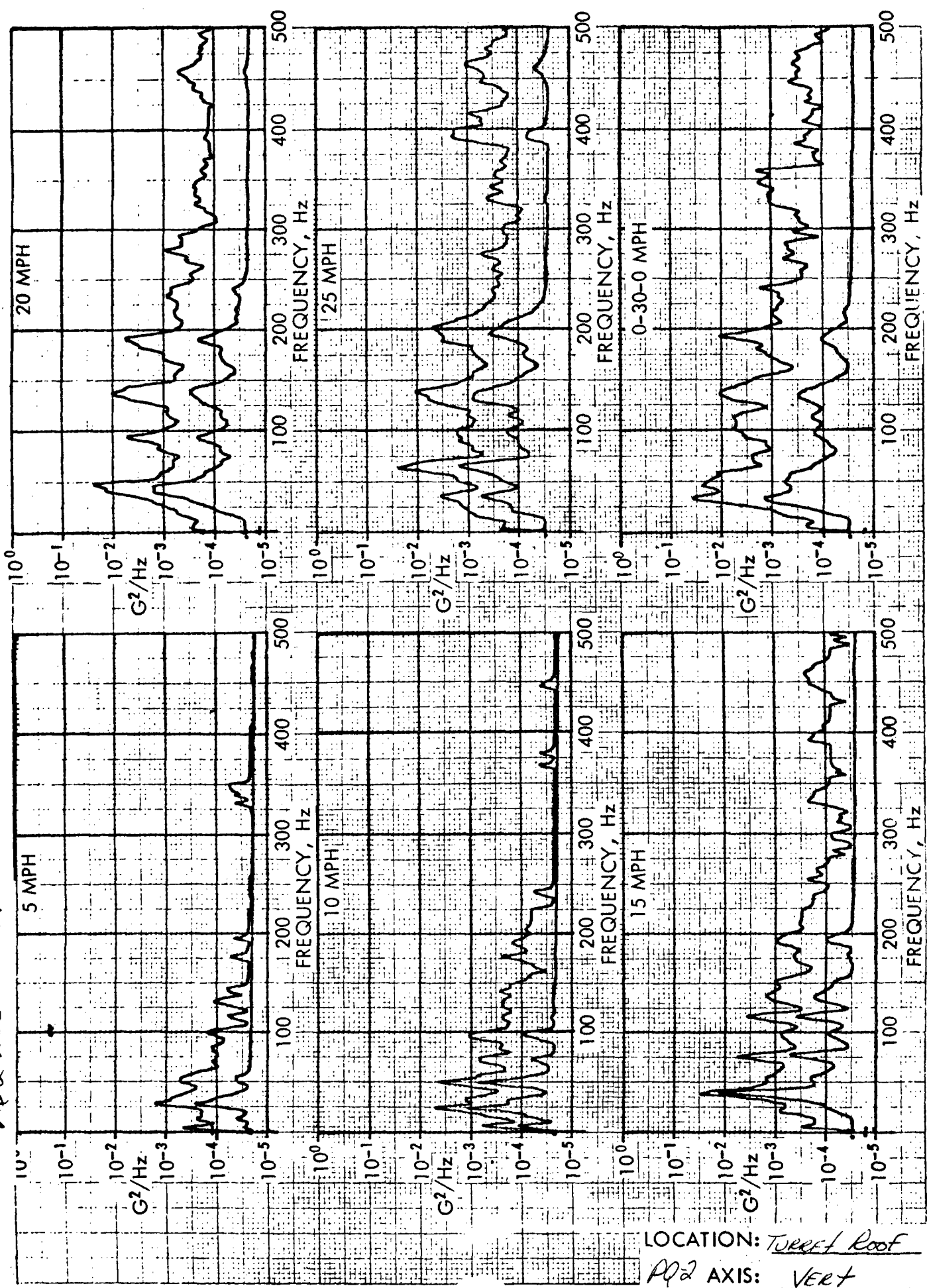
LOCATION: PERISCOPE HENCO
 PQ2 AXIS: TRANS

775Vib
PQ2 - Loc 2 LONG



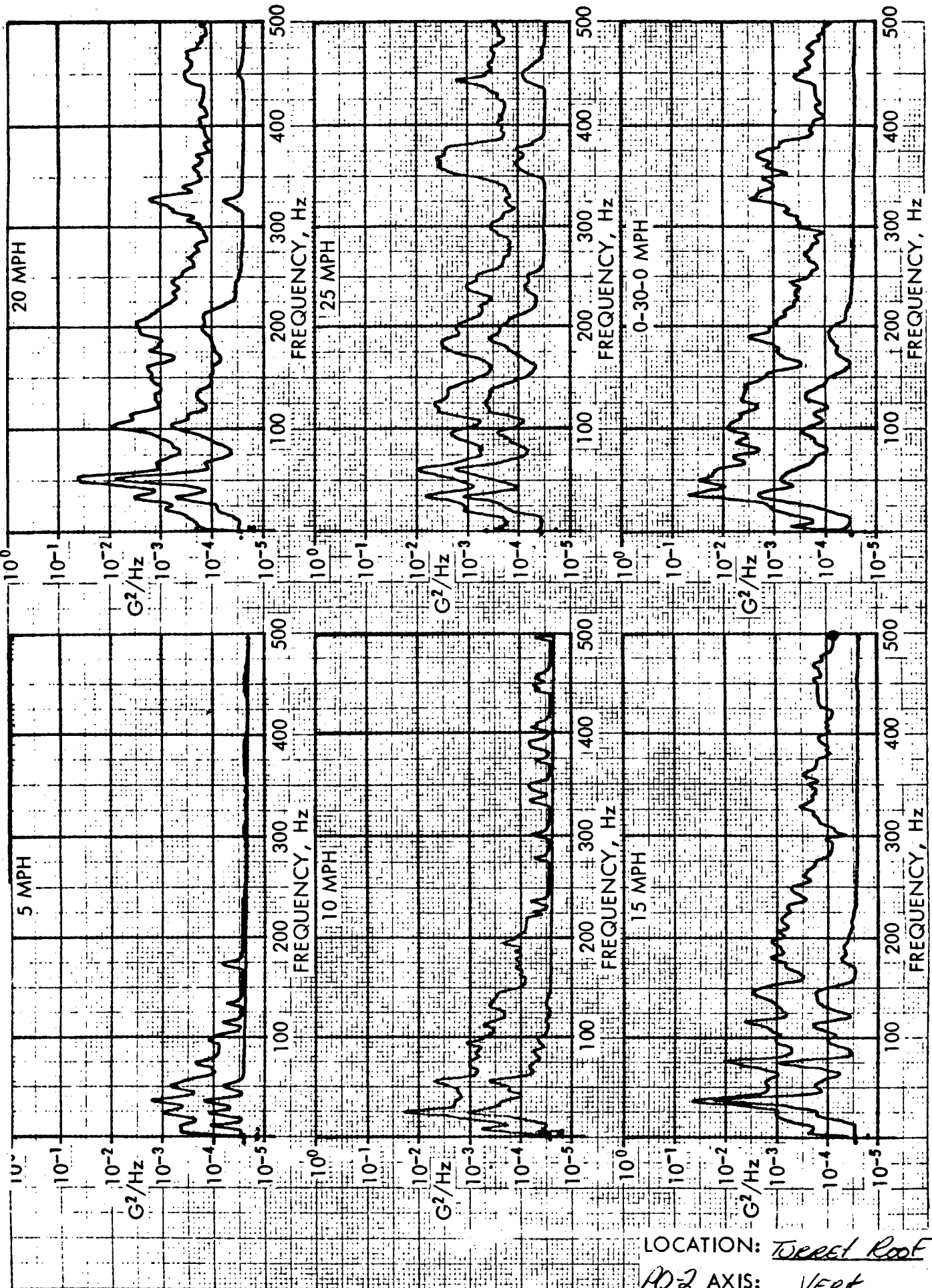
LOCATION: PERISCOPE HEAD
PQ-2 AXIS: LONG

TTS VIB
 PQ2 LOC 3 VERT RUN #1



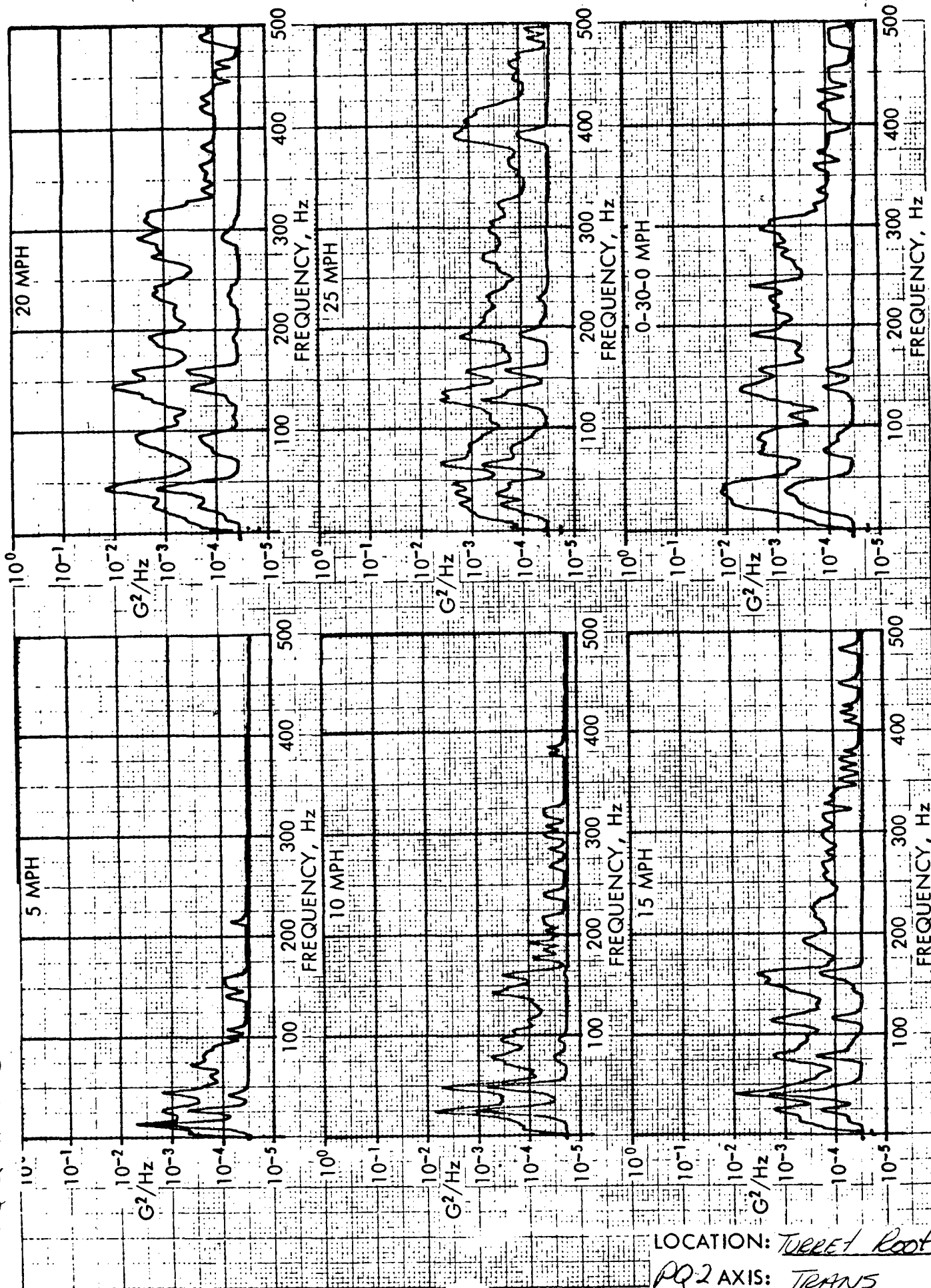
LOCATION: Turret Roof
 PQ2 AXIS: VERT

TTS V16
PQ-2 Loc 3 Vert Rev 6-2



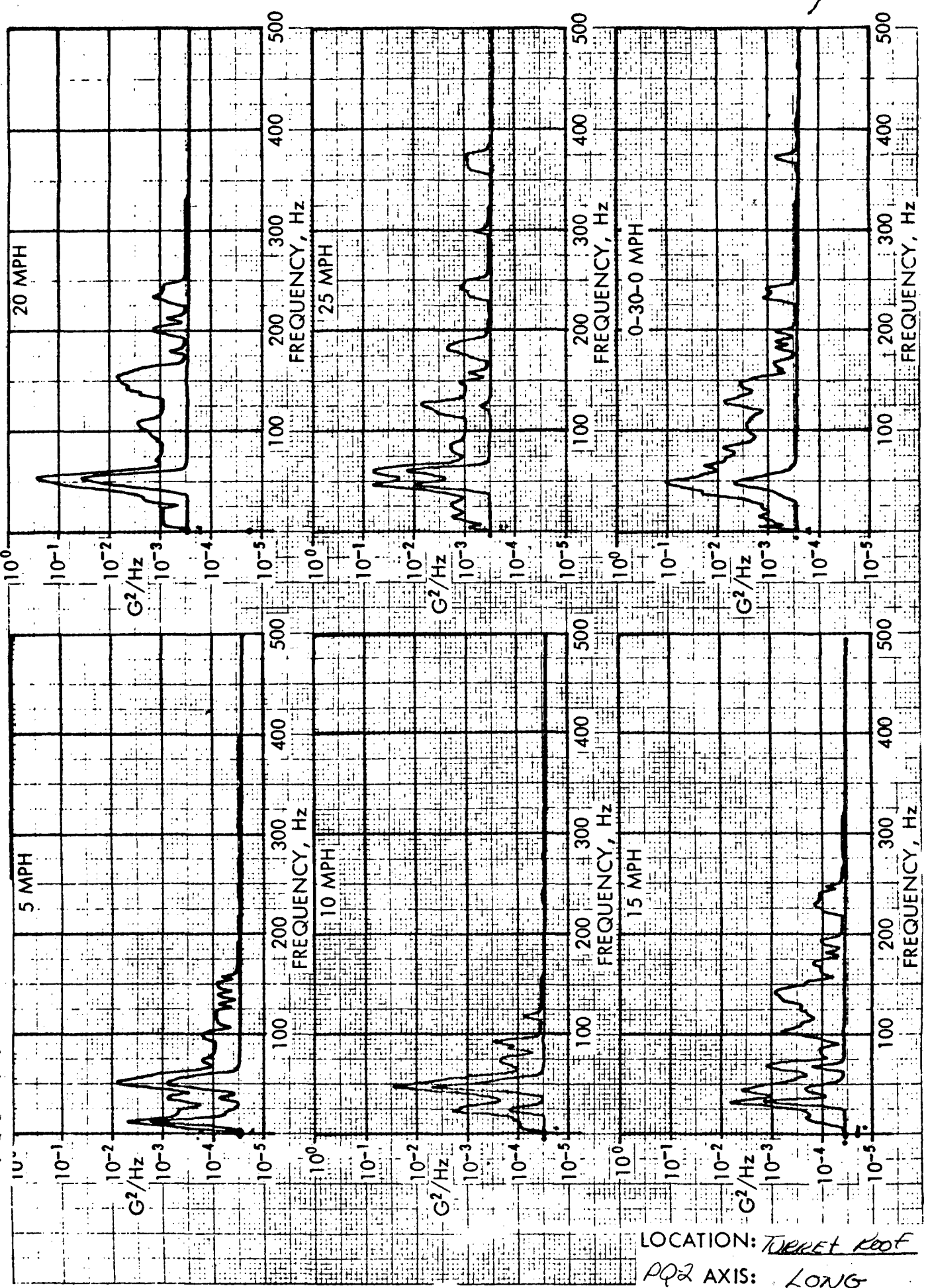
LOCATION: Turret Roof
PQ-2 AXIS: VERT

TTS VIB
PQ2 LOC 3 TRANS



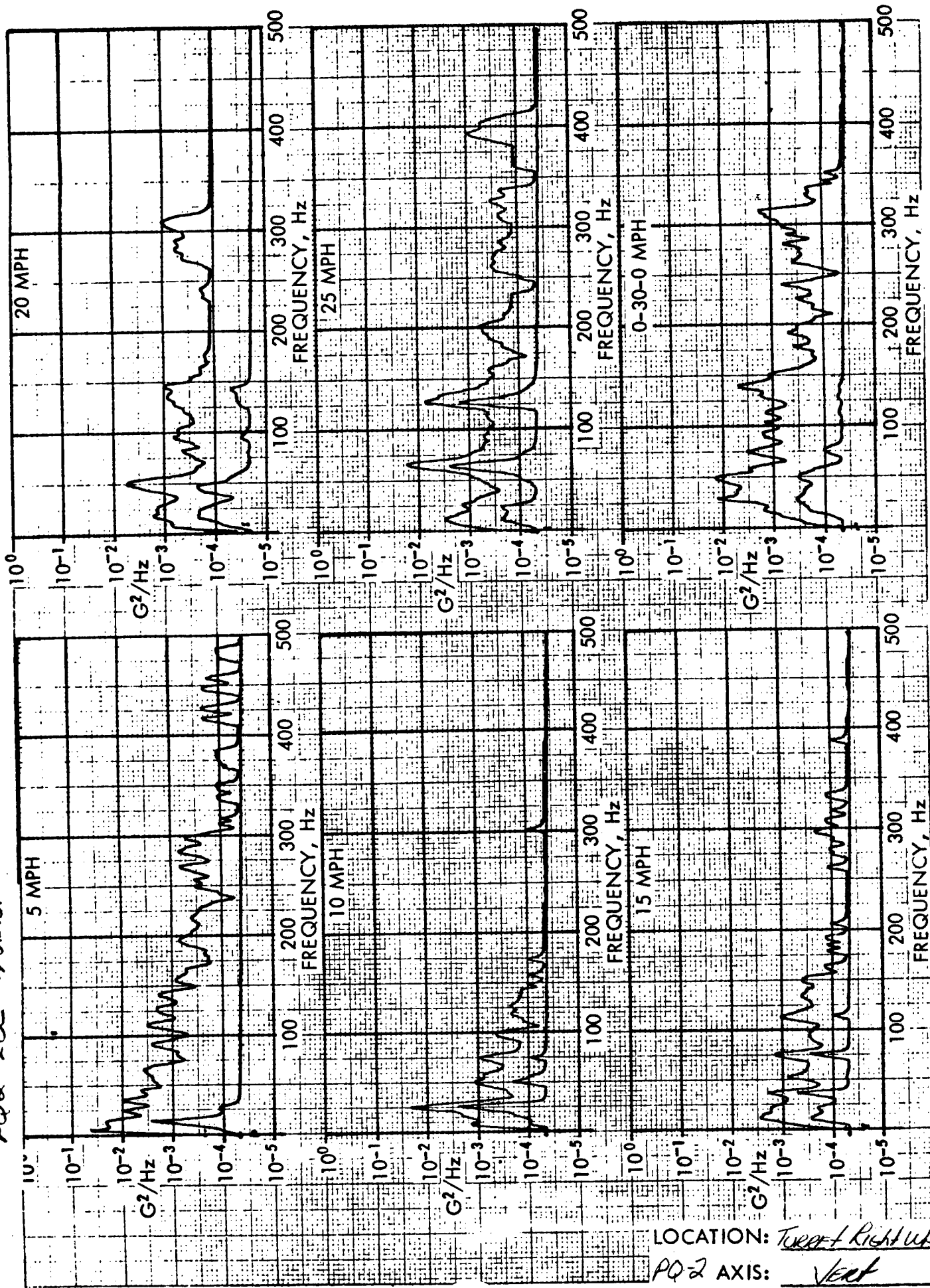
LOCATION: Turret Roof
PQ2 AXIS: TRANS

775 Vib
PQ2 103 LONG



LOCATION: TURRET ROOF
PQ2 AXIS: LONG

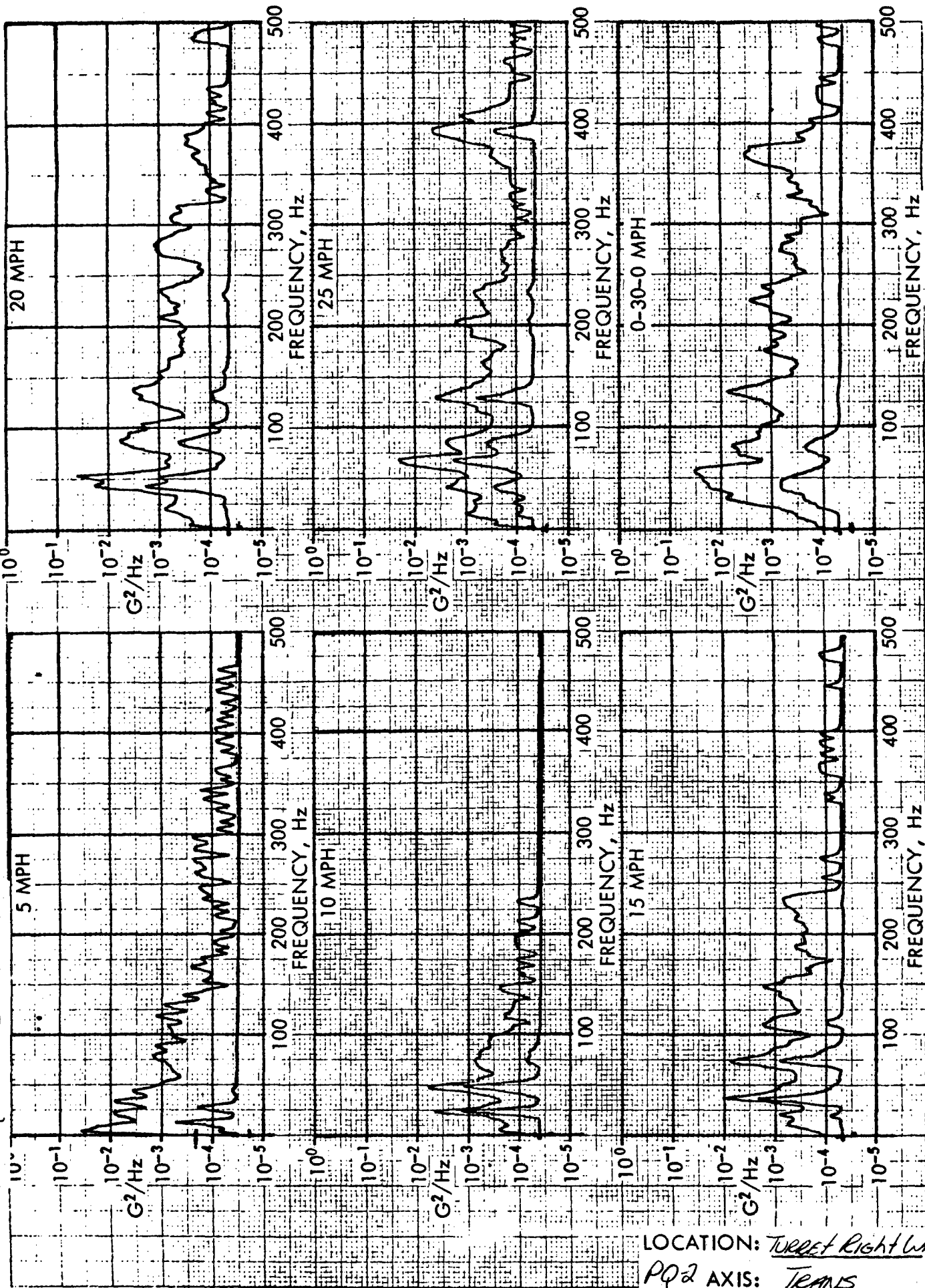
775 Vib
PQ2 LOC 4 Vert



LOCATION: Turret Right Wall
PQ2 AXIS: Vert

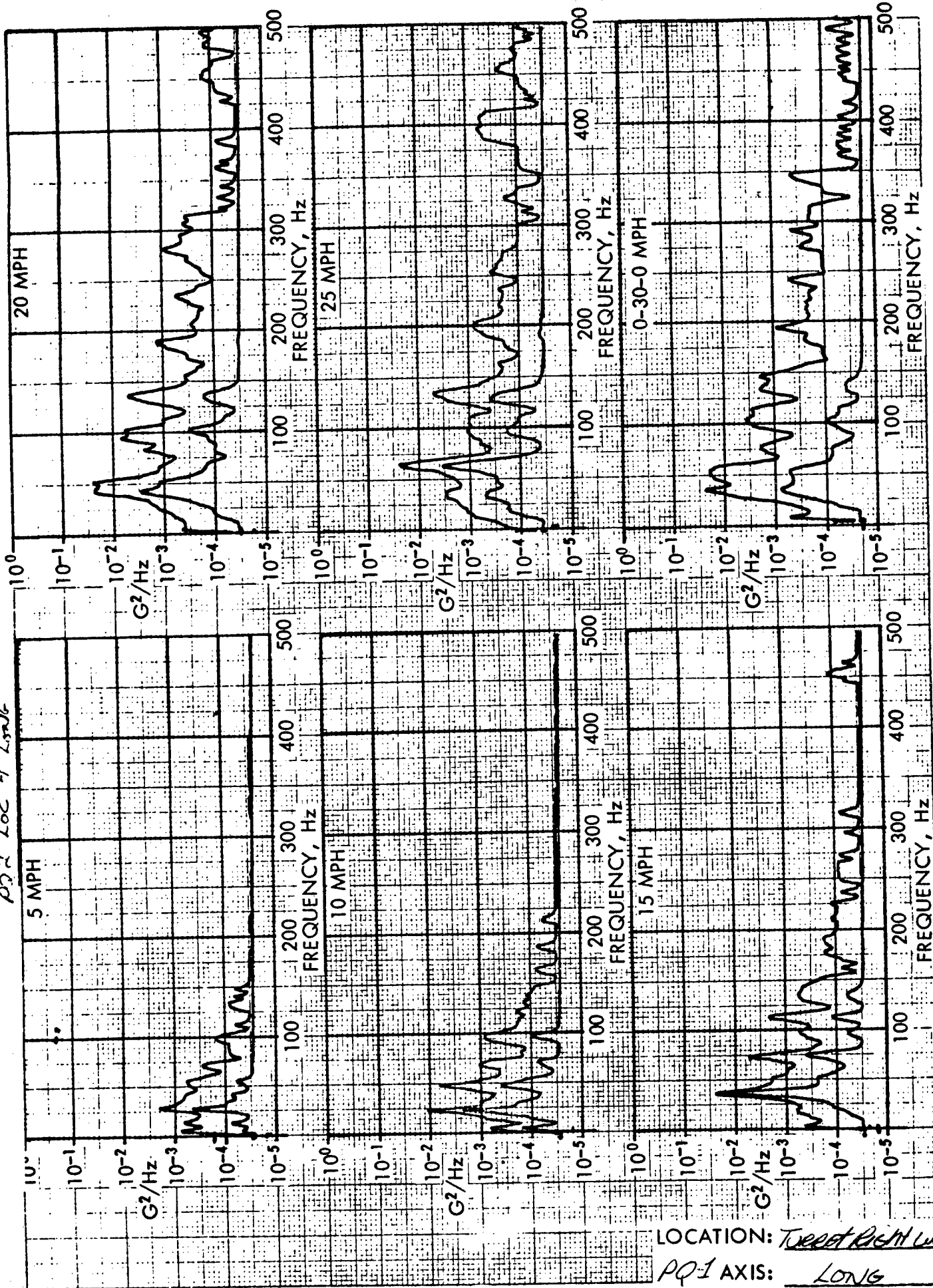
TTS VIB

PQ2 LOC 41 Trans



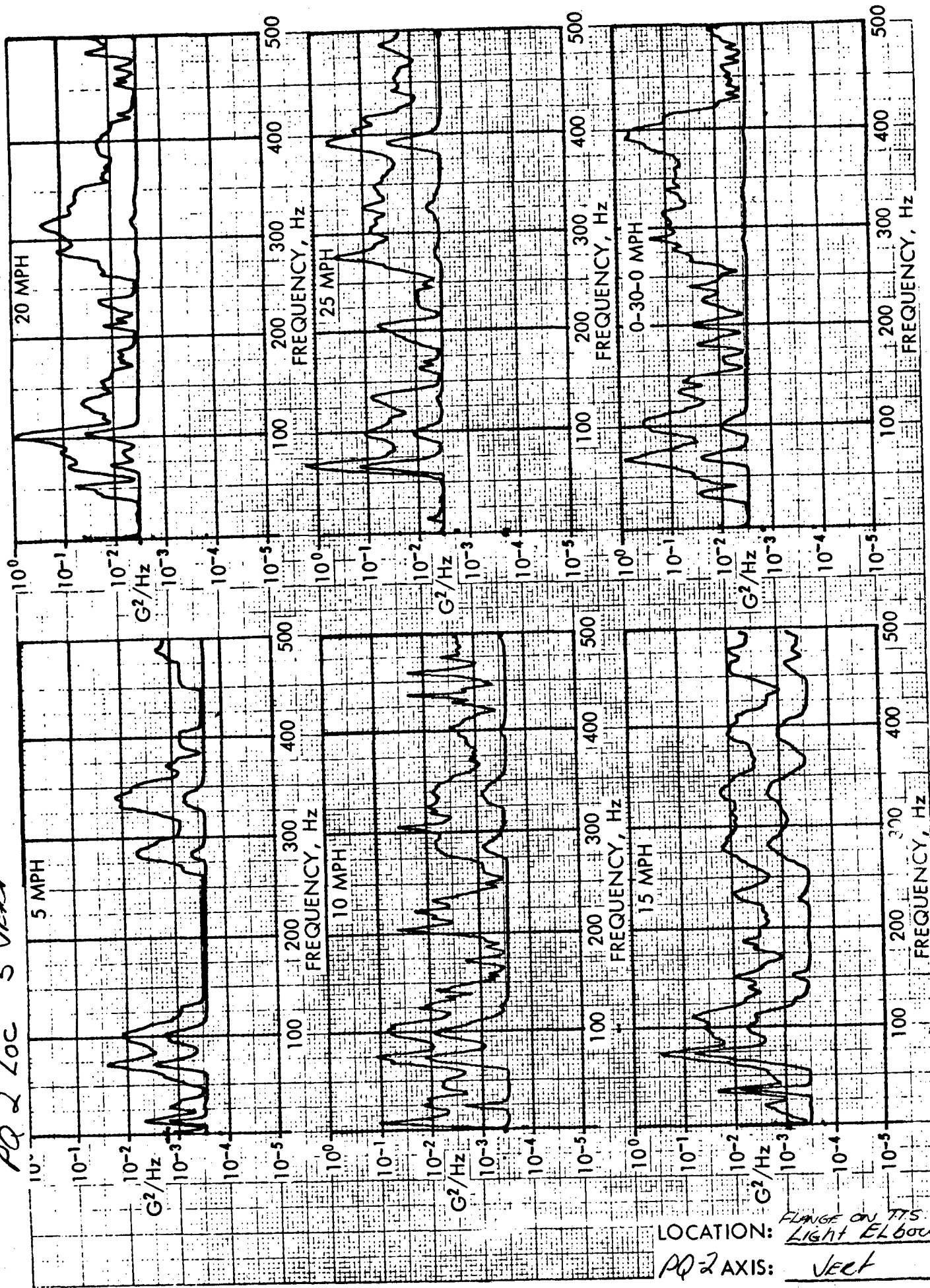
LOCATION: Turret Right Wall
PQ2 AXIS: TRANS

775 vib
 P22 Loc 4 Long



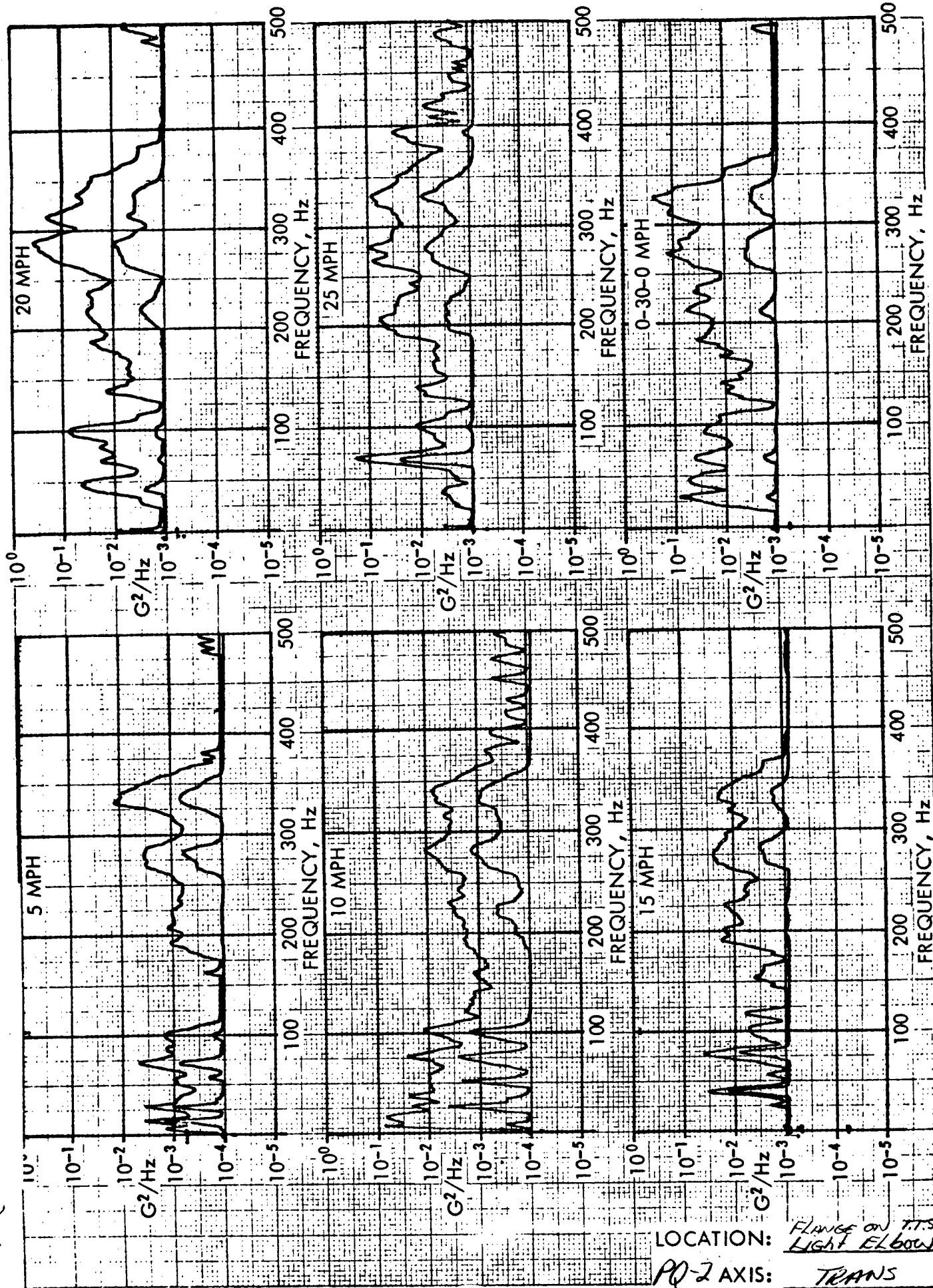
LOCATION: Turret Right Wall
 PQ-1 AXIS: LONG

TTS V.I.B
PQ-2 LOC 5 VERT

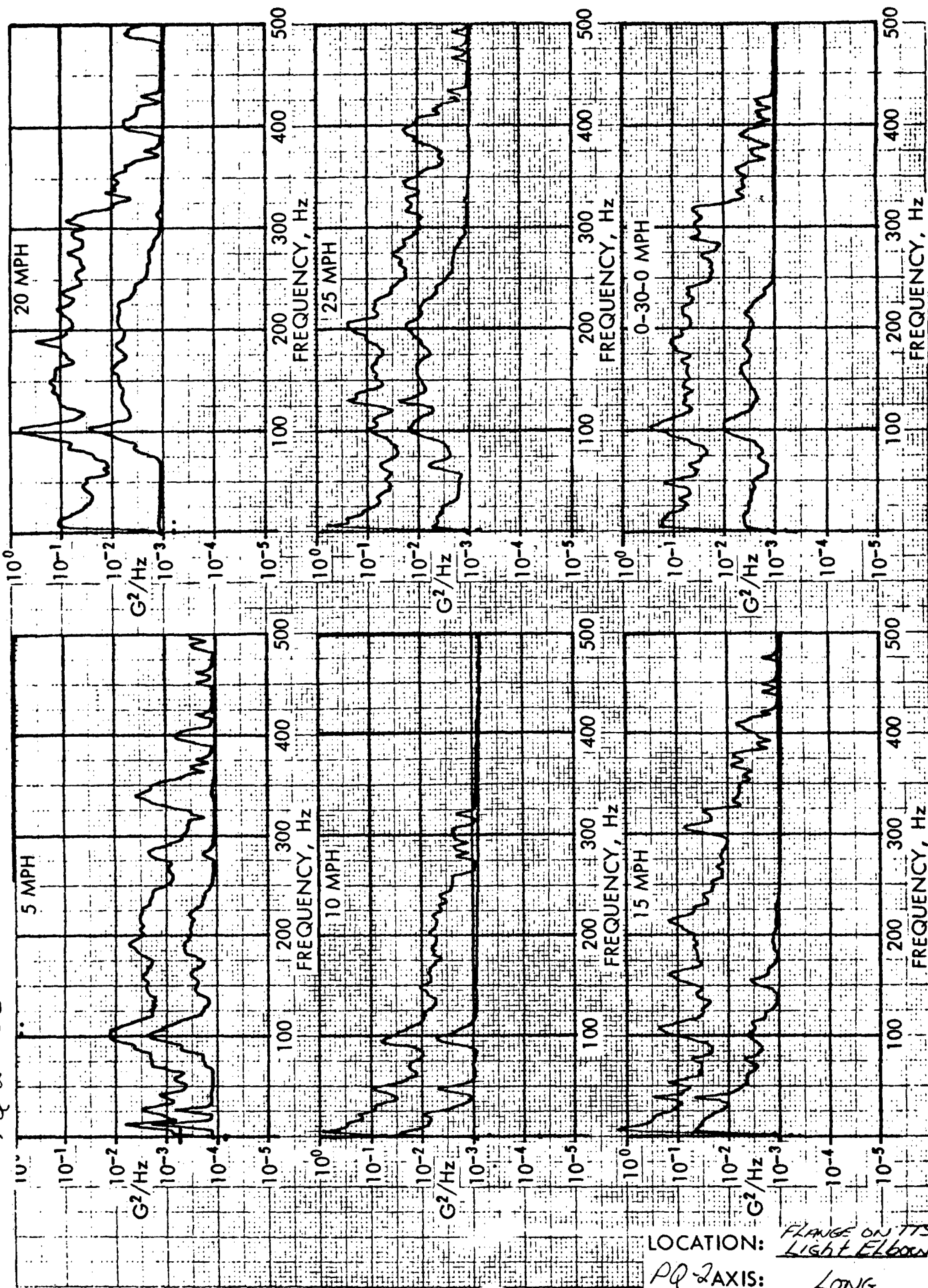


LOCATION: FLANGE ON TTS
Light Elbow
PQ-2 AXIS: VERT

TTS Vib
PQ-2 LOC 5 TRANS

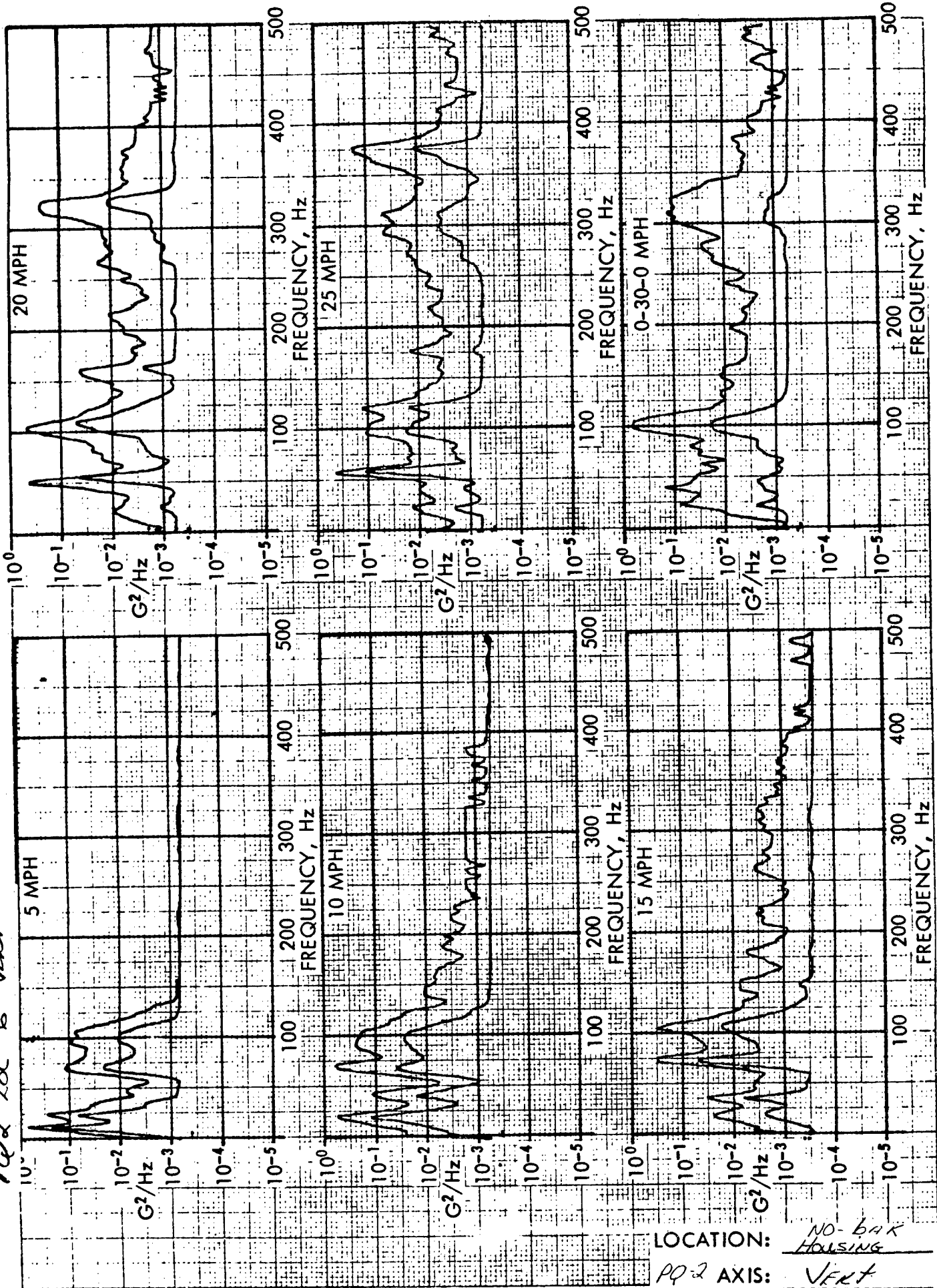


TTS Vi6
 AQ 2 LOC 5 LONG



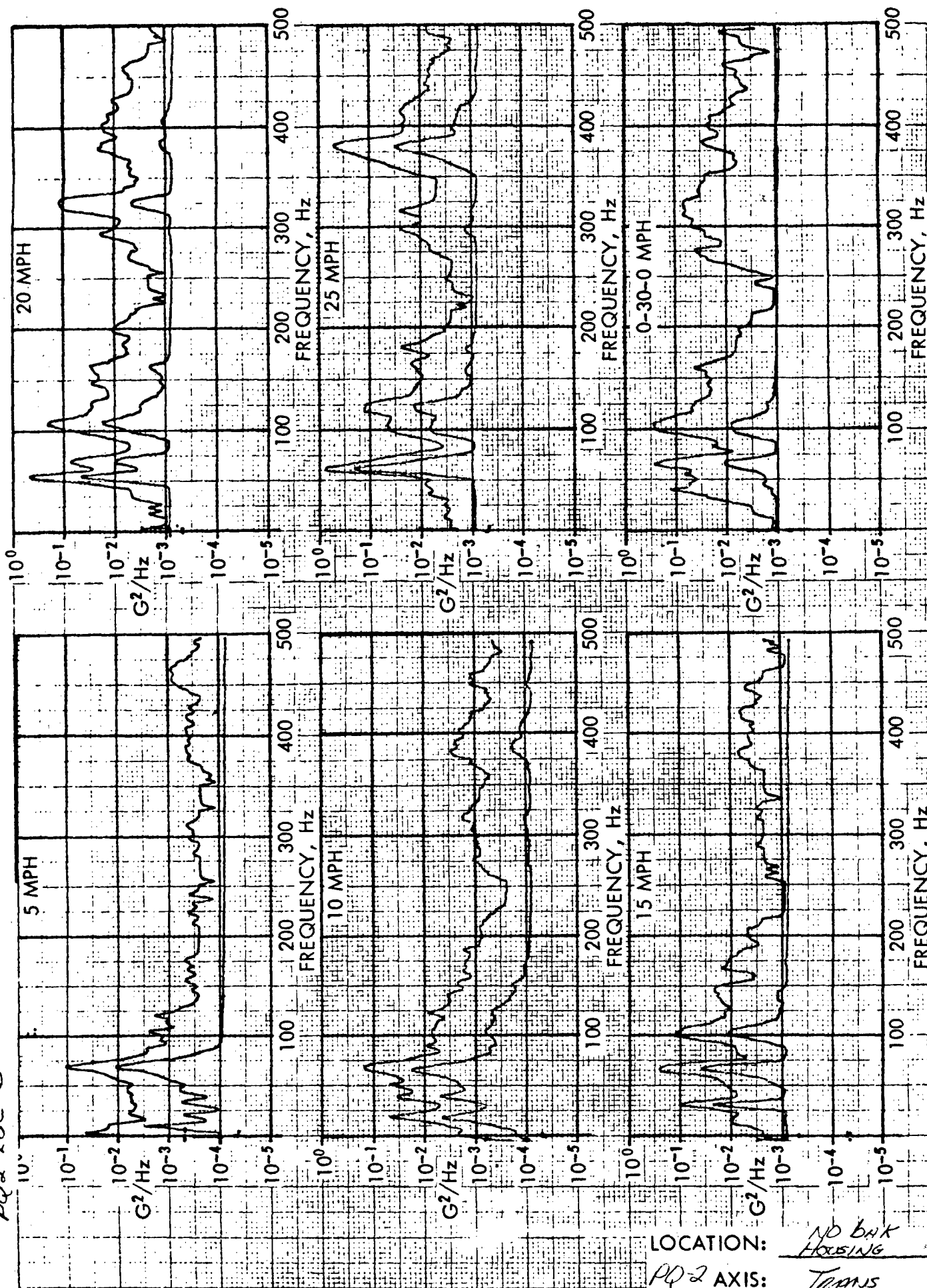
LOCATION: FLANGE ON TTS
 LIGHT ELBOW
 PQ-2 AXIS: LONG

TTS Vib
PQ-2 Loc 6 Vert



LOCATION: NO-BACK HOUSING
PQ-2 AXIS: VERT

TTS V16
PQ2 LOC 6 TRANS



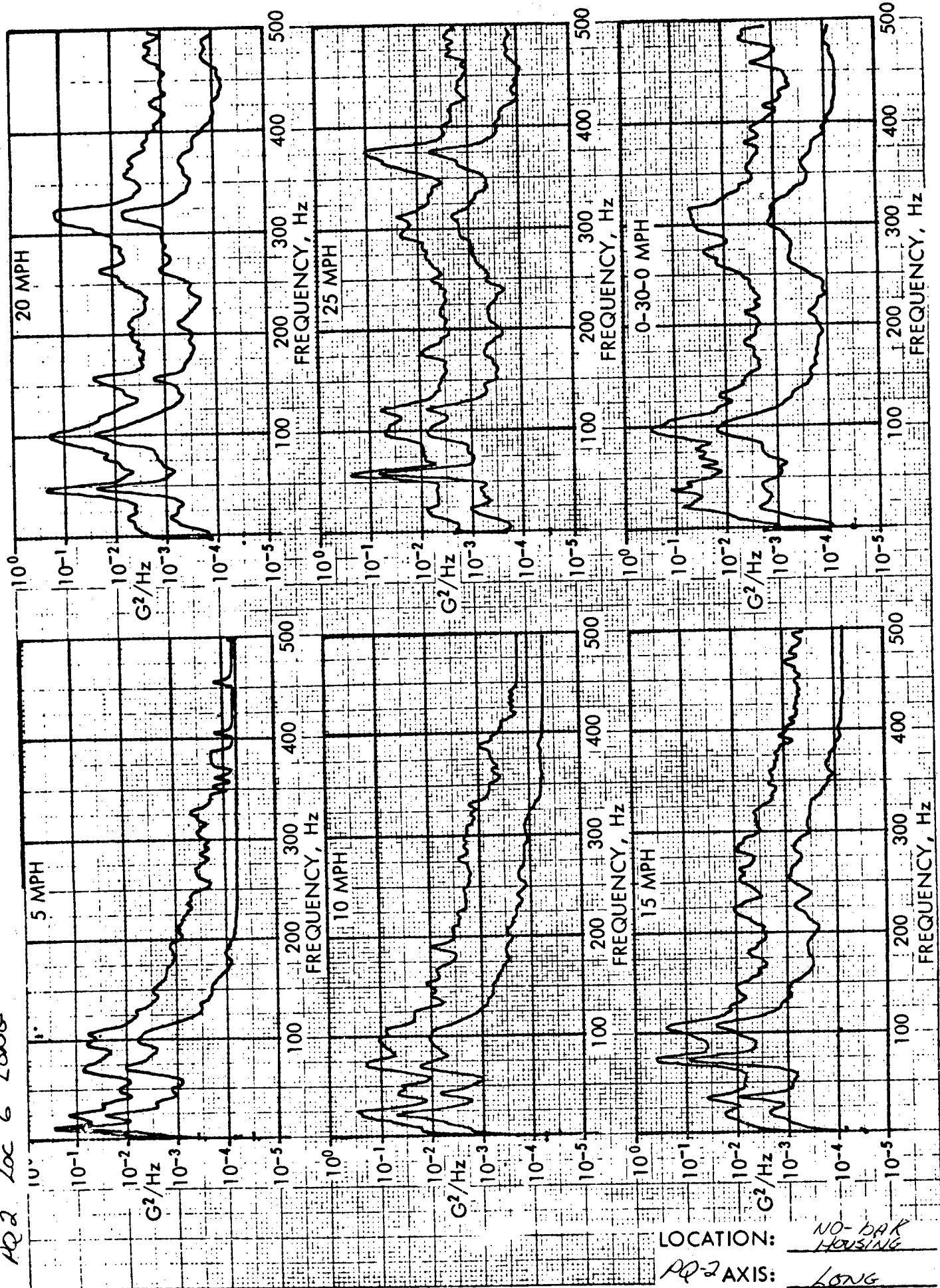
LOCATION:

PQ-2 AXIS:

NO BACK
HOUSING

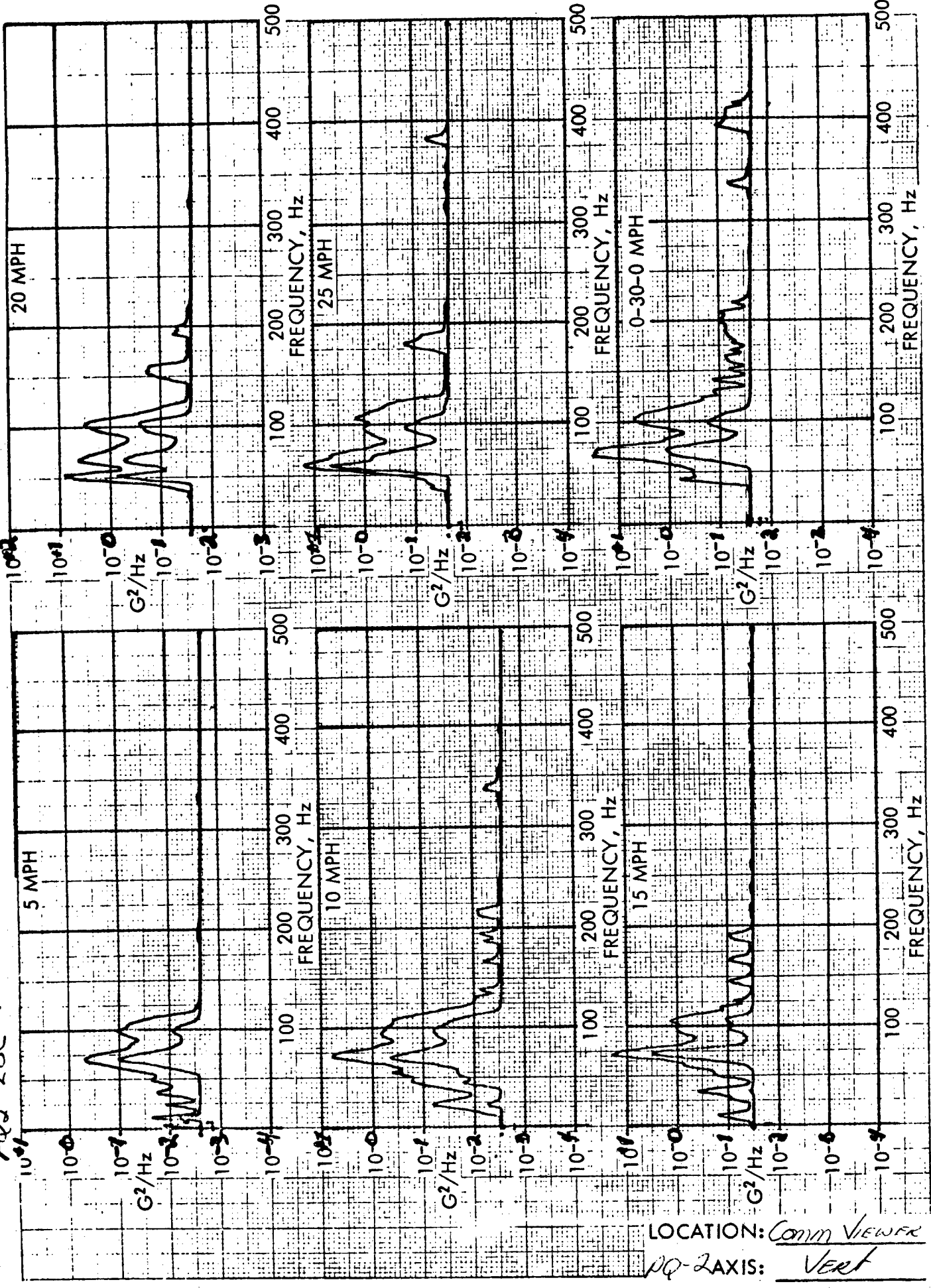
TRANS

775 Vib
HQ2 Loc 6 Long



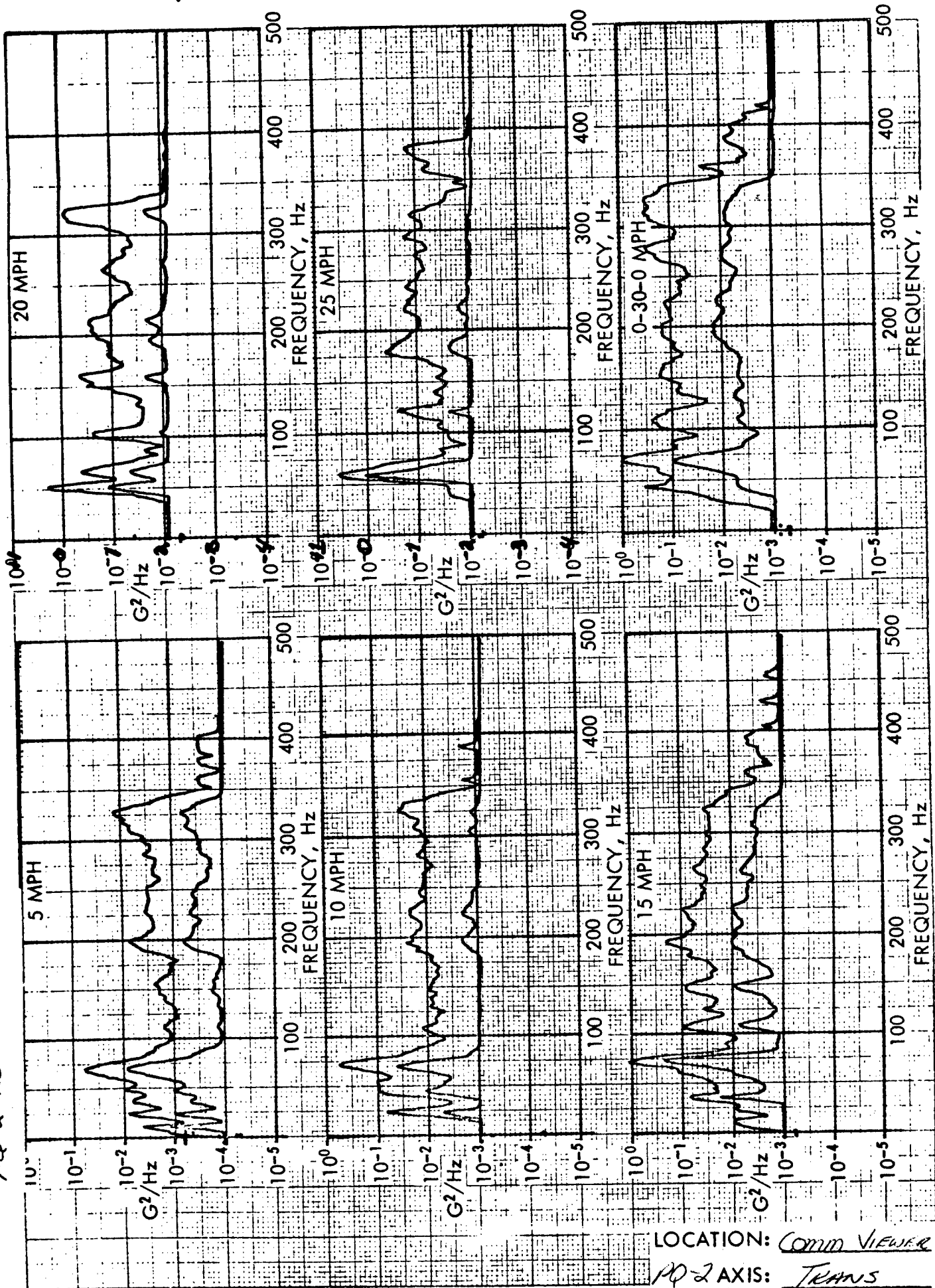
LOCATION: NO-DARK HOUSING
PQ-2 AXIS: LONG

775 Vib
PQ2 LOC 7 Vert



LOCATION: Comm View
PQ-2 AXIS: Vert

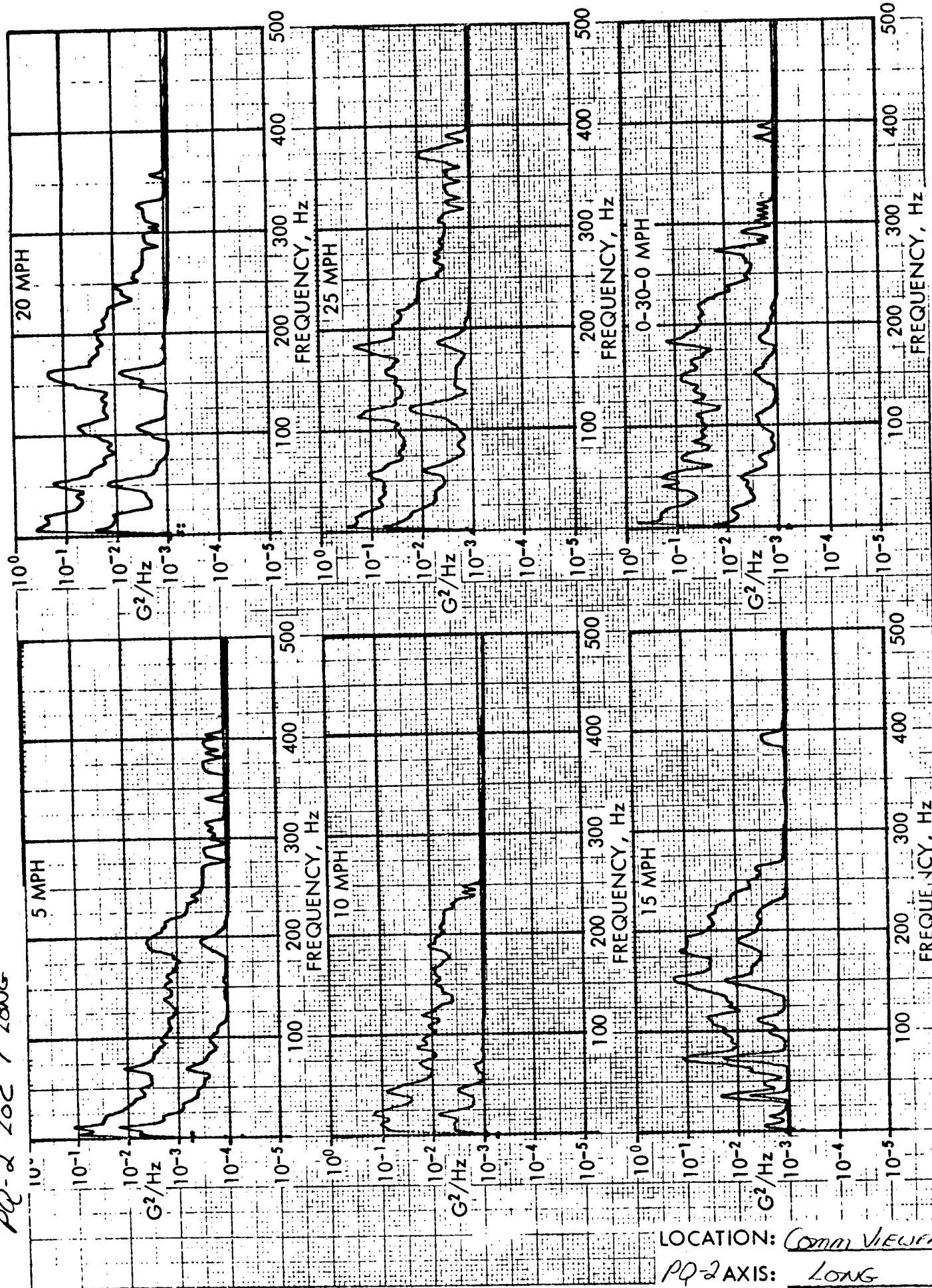
TTS V6
 PQ 2 LOC 7 TRANS



LOCATION: COMM VIEWER
 PQ-2 AXIS: TRANS

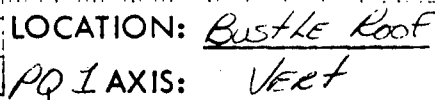
TTS Vib

PQ-2 LOC 7 Long

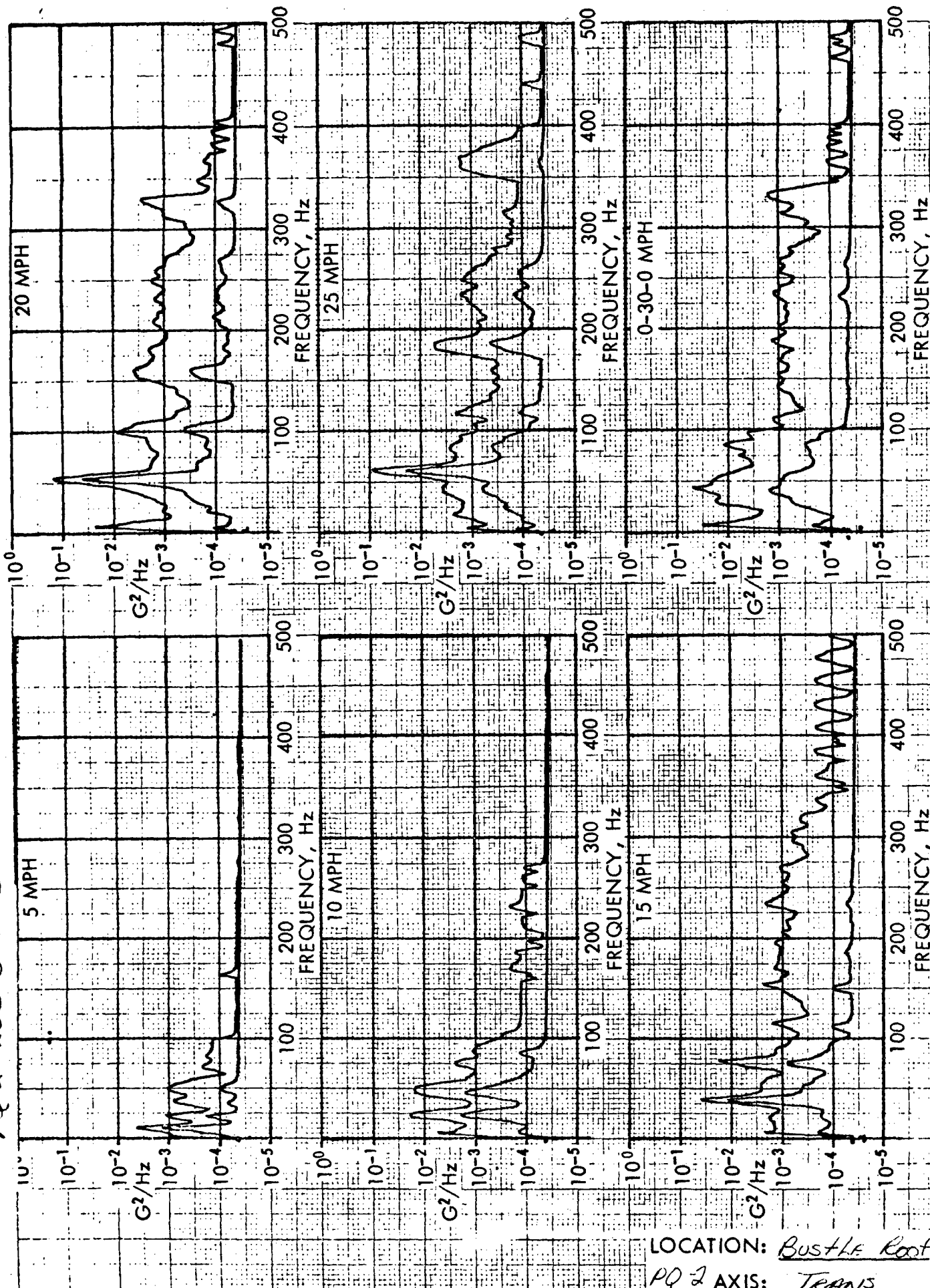


LOCATION: COMM VIEWER
 PQ-2 AXIS: LONG

11-5 v12
PQ2 Loc 8 vend

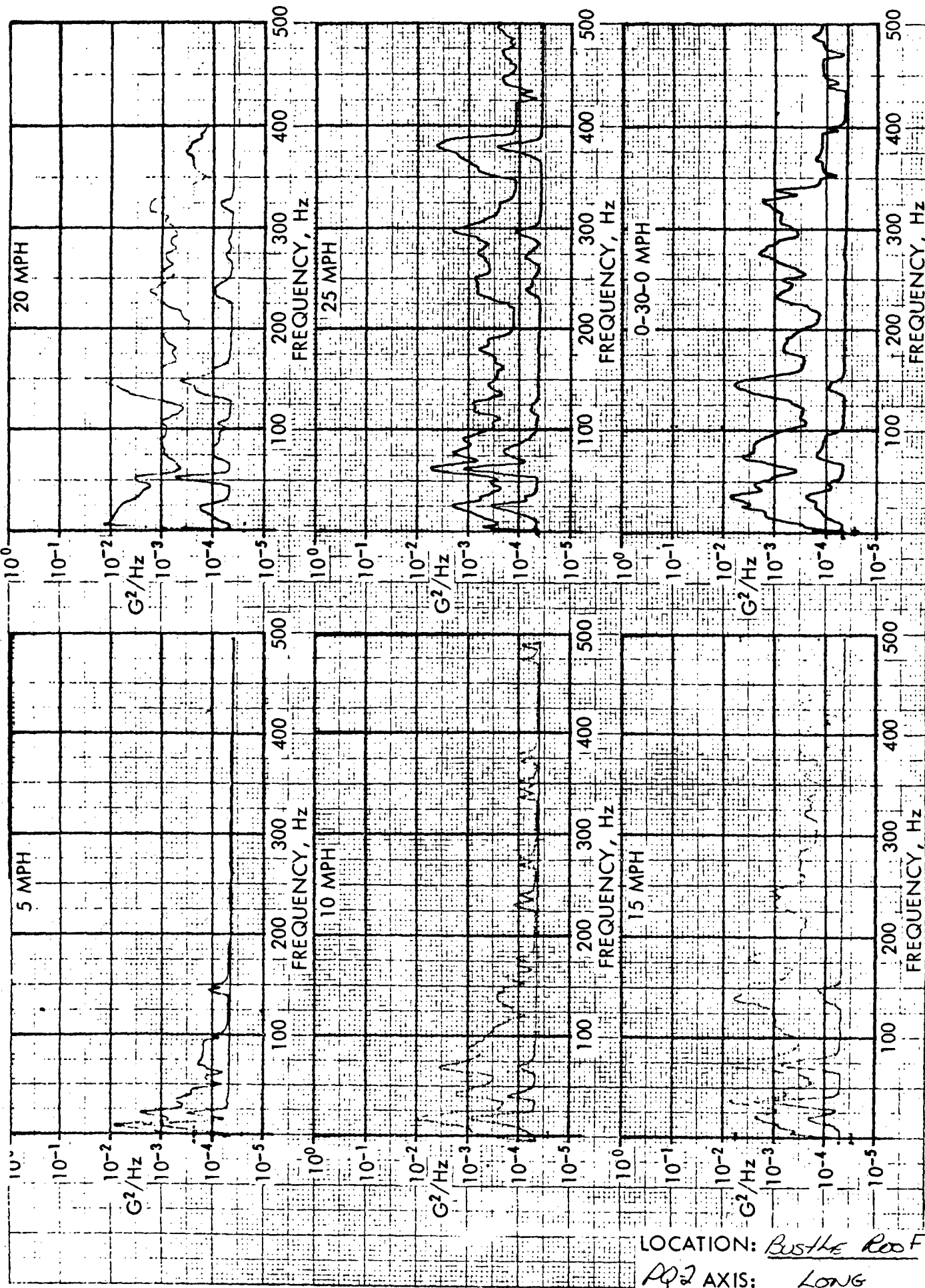


775 Vis
PQ 2 LOC 8 Trans

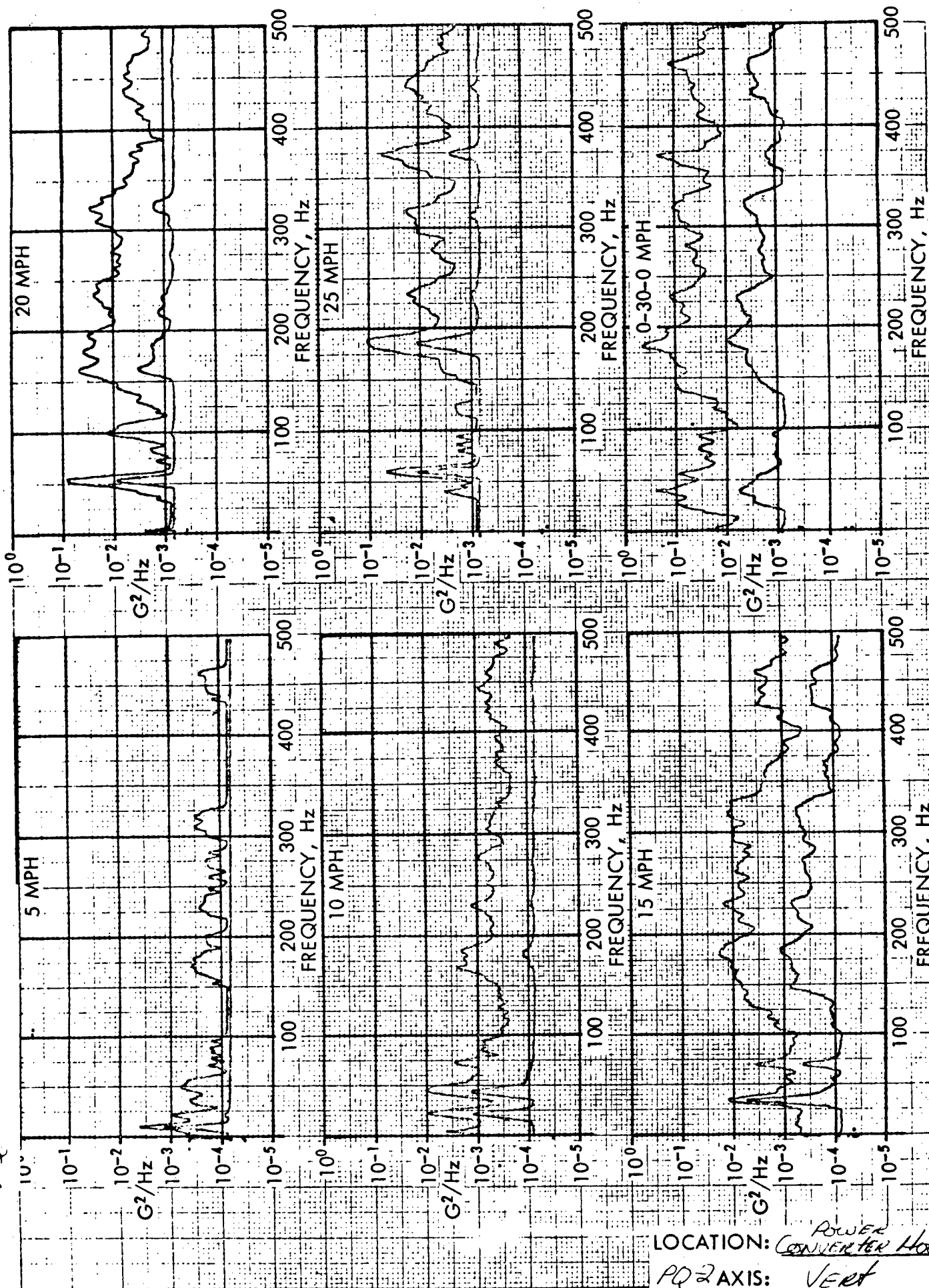


LOCATION: BUSTLE ROOF
PQ 2 AXIS: TRANS

TTS Vib
PQ2 LOC 3 LONG

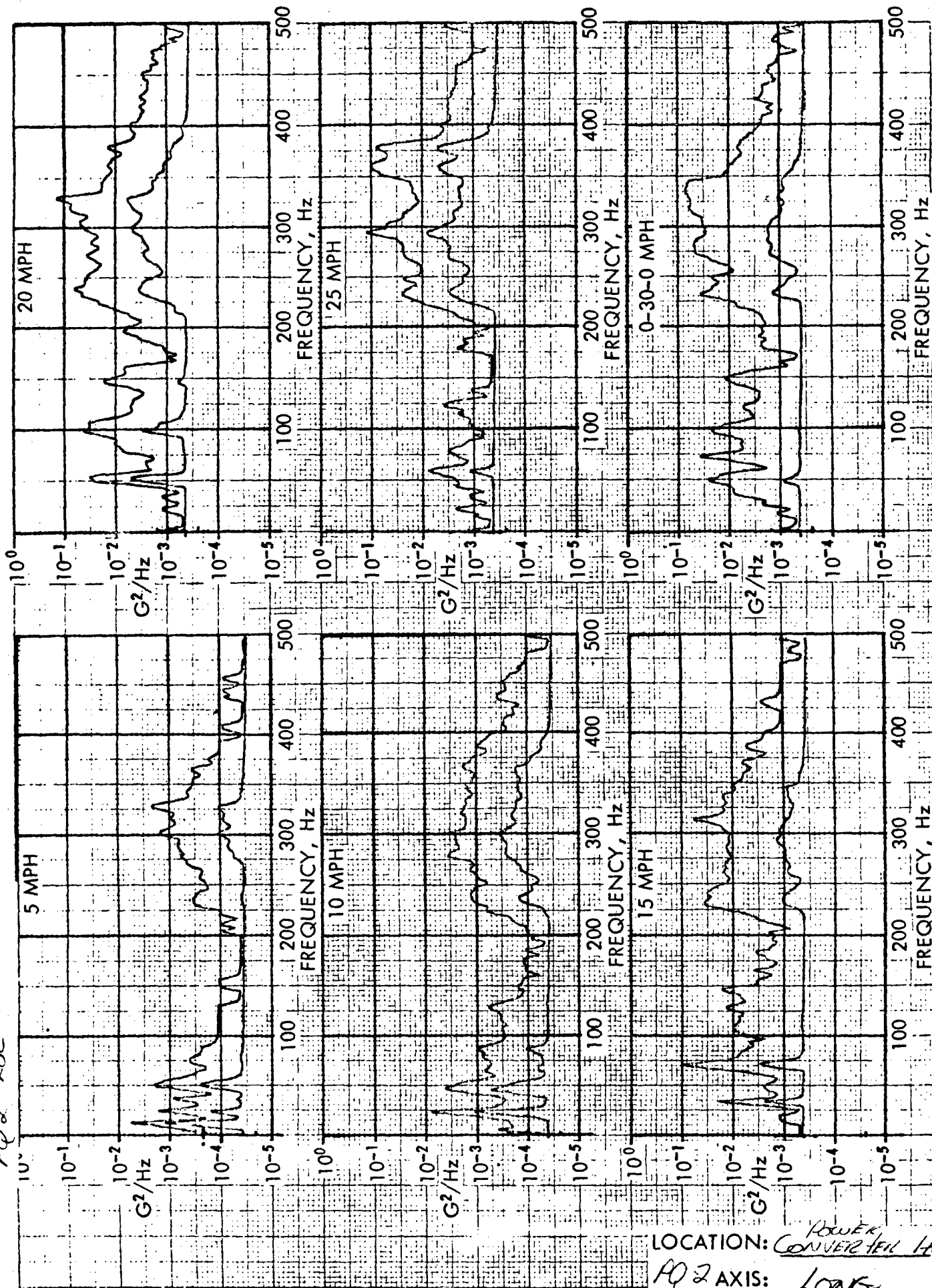


TTS V16
A02 LOC 9 TRANS



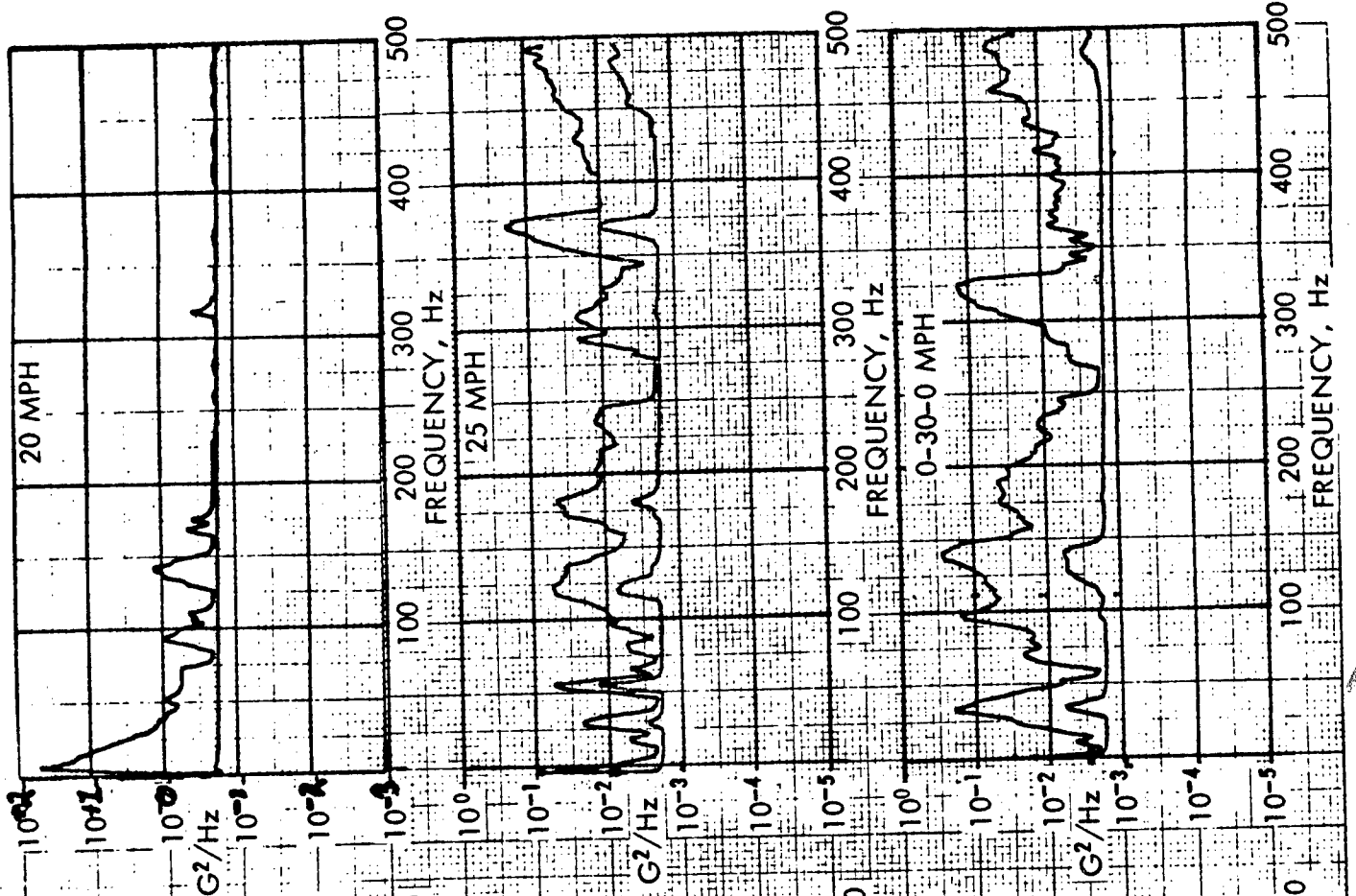
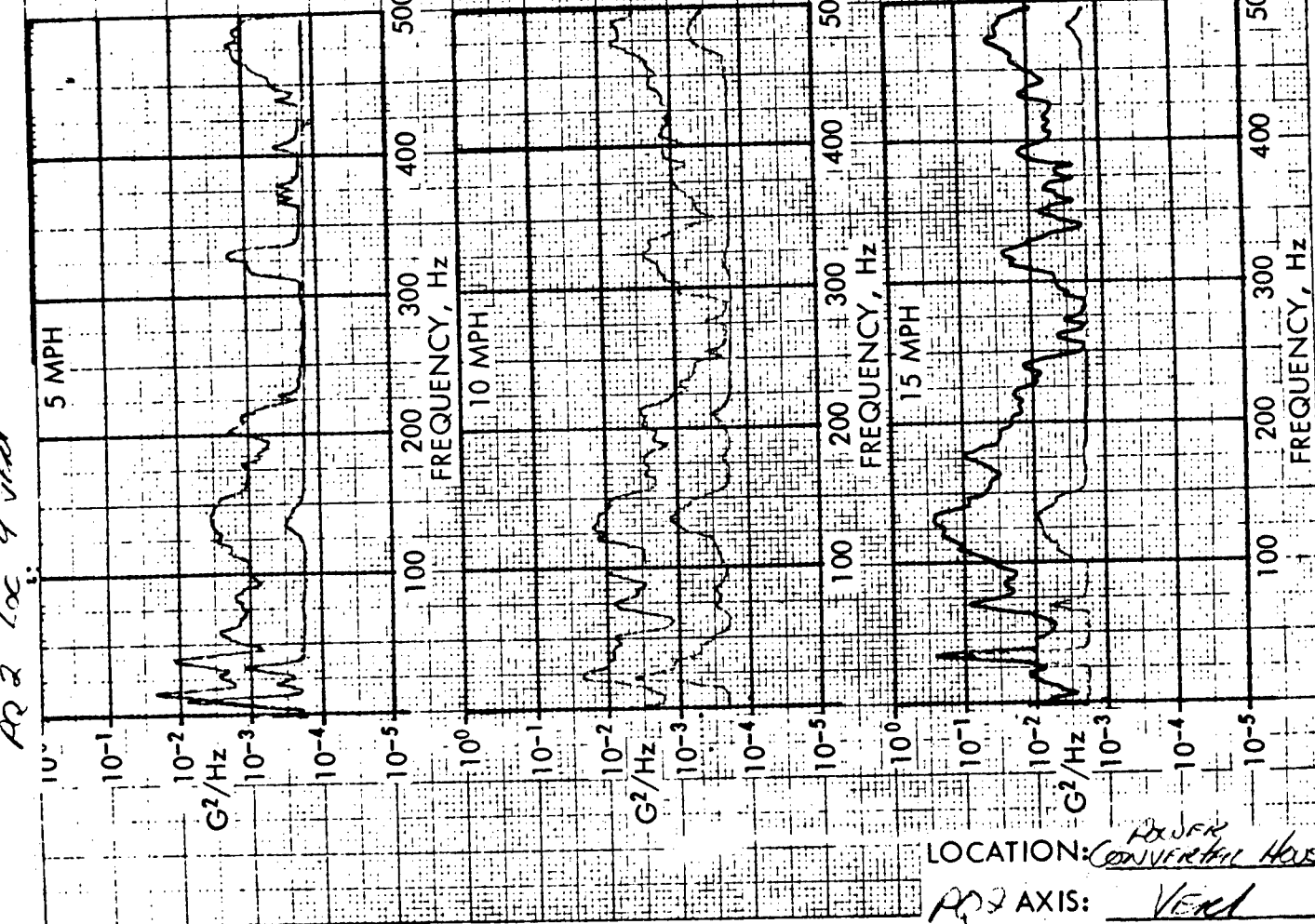
LOCATION: POWER CONVERTER HOUSING
PQ2 AXIS: VERT

775 Vib
 PQ2 Loc 9 Long



LOCATION: ^{POWER} CONVERTER HOUSE
 PQ2 AXIS: LONG

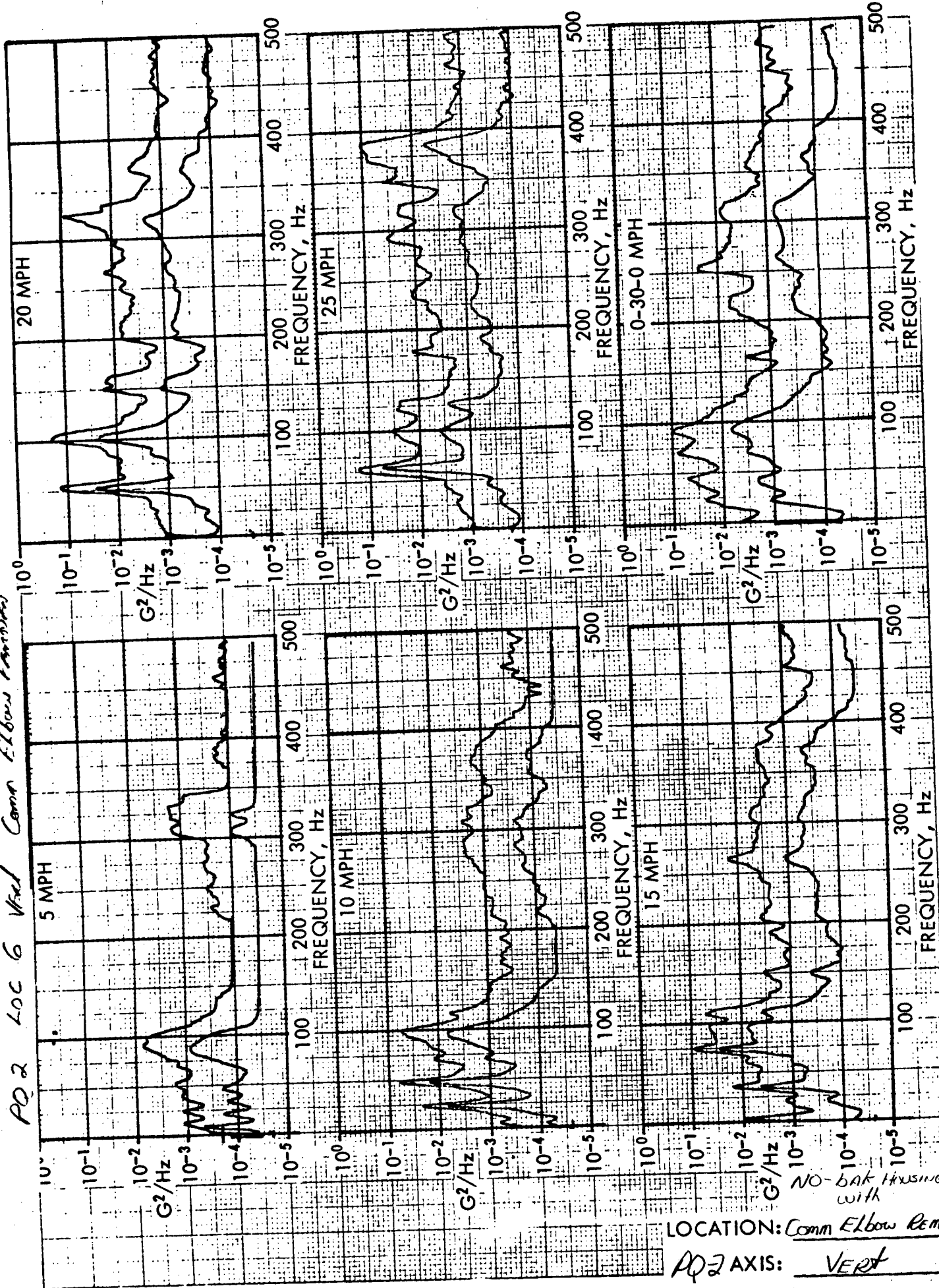
TTS V13
 R22 Loc. 9 vert



LOCATION: ^{POWER} CONVEYER HOUSING
 R22 AXIS: VERT

775 Jil

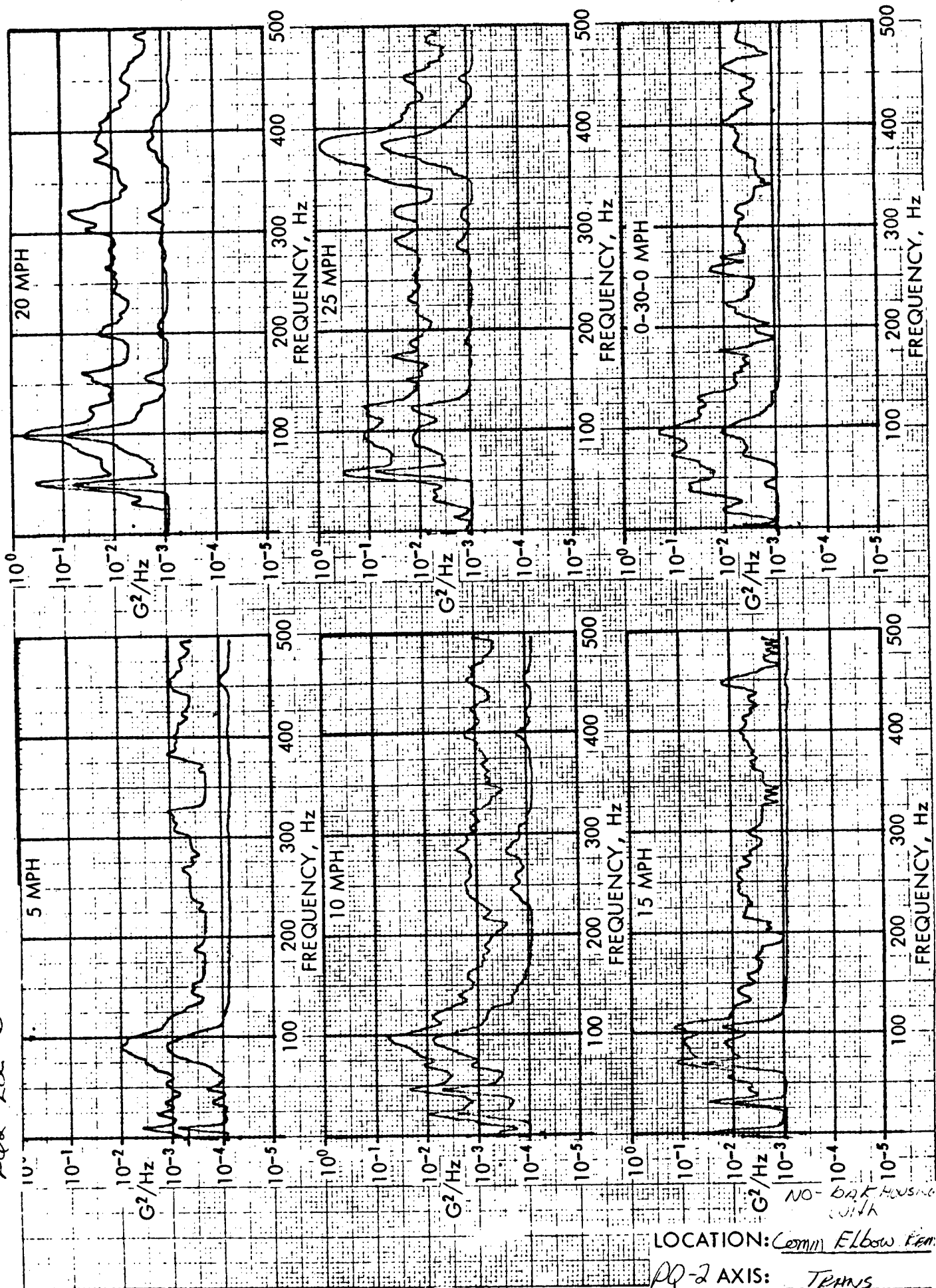
PQ-2 LOC 6 Vert Comm Elbow Fanout



LOCATION: Comm Elbow REMOVED

PQ-2 AXIS: VERT

TTS Vib
 PQ2 LOC 6 Trans Comm Elbow Resonance



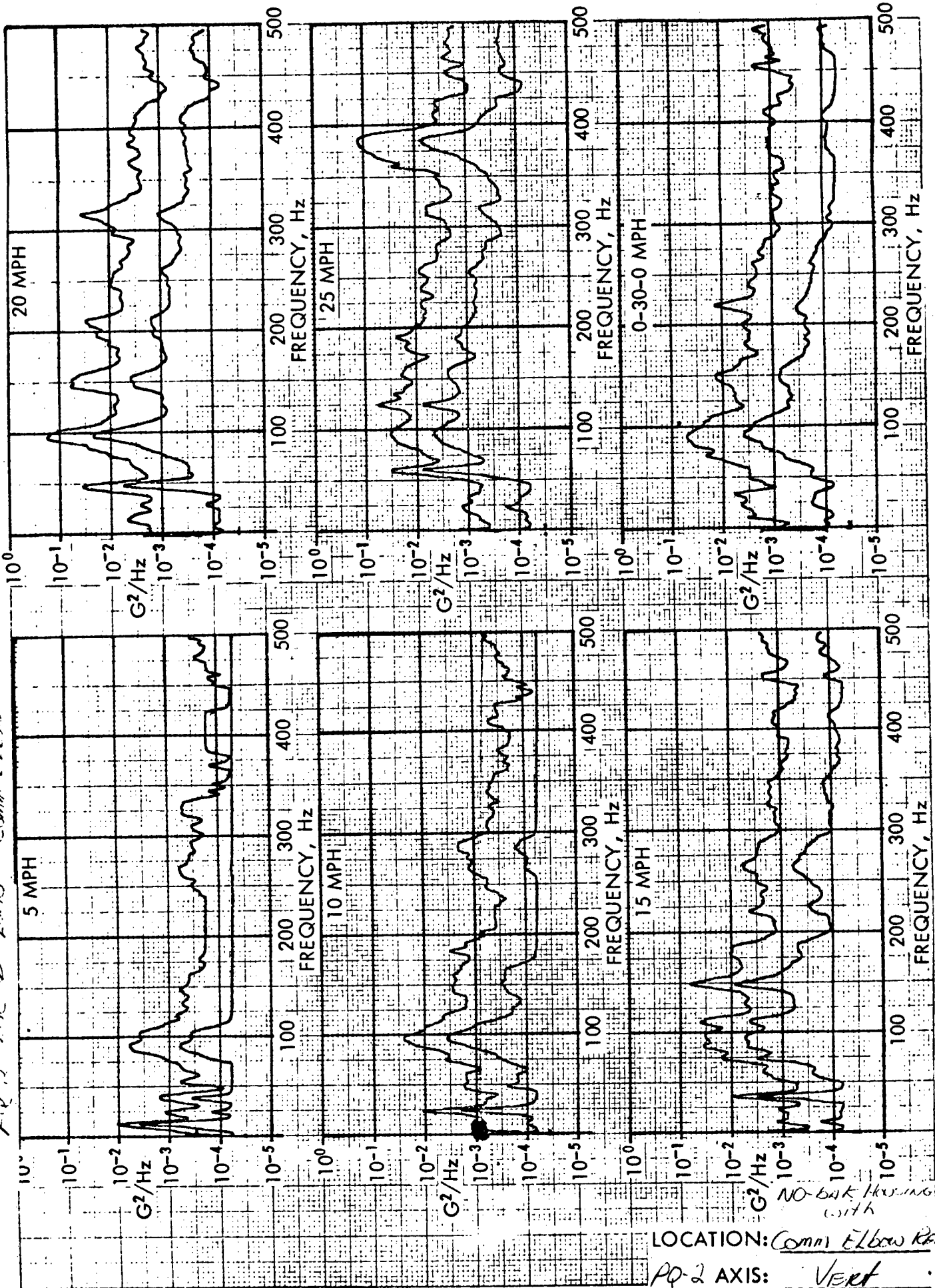
NO-DRY HOUSING WITH

LOCATION: Comm Elbow Resonance

PQ-2 AXIS: TRANS

775 VLB

PQ-2 line to 10015 Conn Filter removed

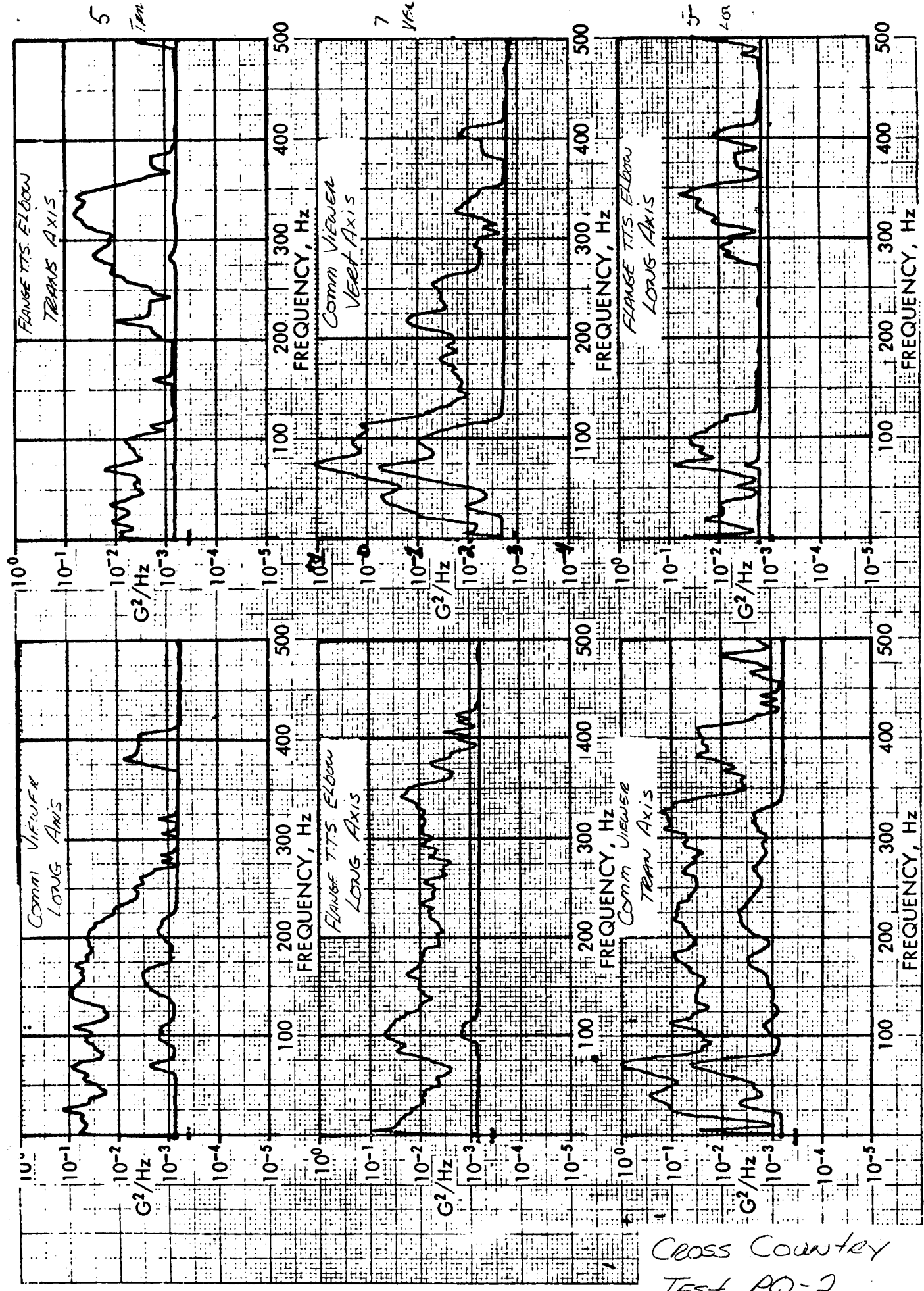


LOCATION: Conn Filter removed

PQ-2 AXIS: Vert

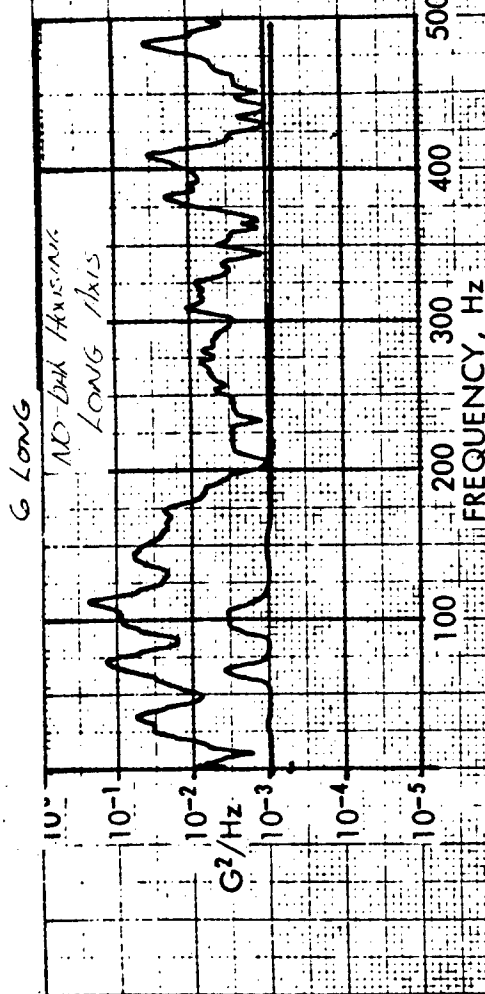
ROAD VIBRATION P.S.D. PLOTS
ON TEST VEHICLE PQ-1 & PQ-2
CROSS COUNTRY
(CONDITION 2)

PQ 2 Cross Country

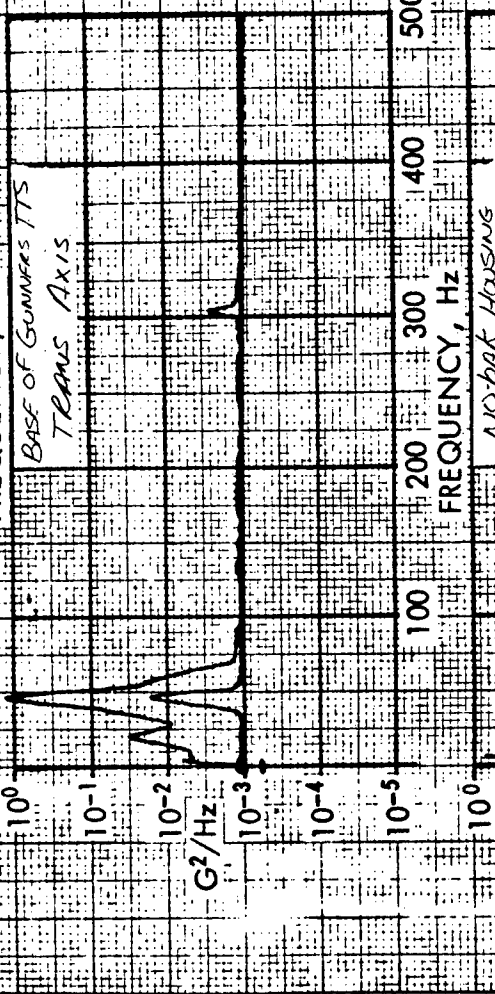


Cross Country
TEST PQ-2

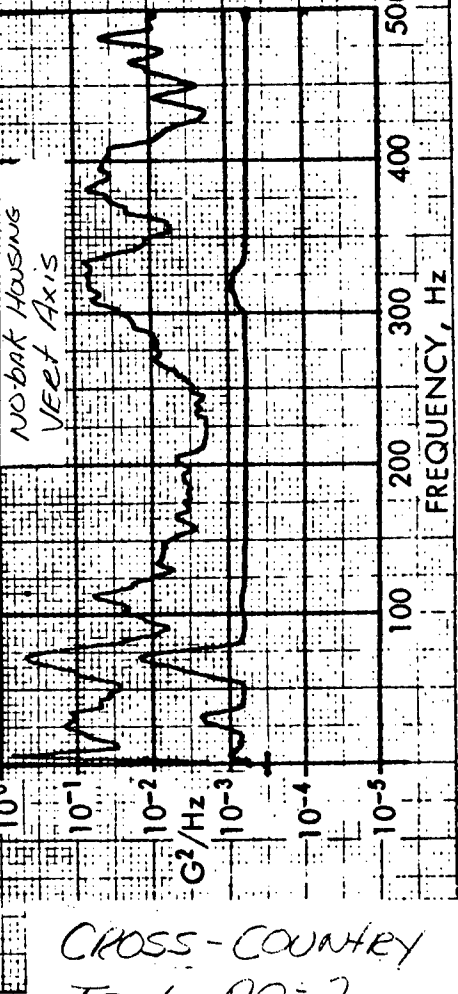
6 Long



BASE OF GUNFAS TTS
TRANS AXIS

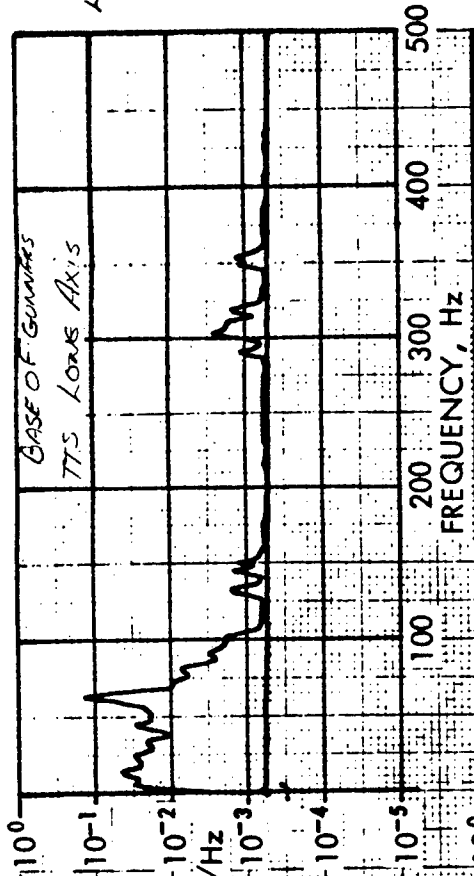


NO-BACK HOUSING
VEET AXIS

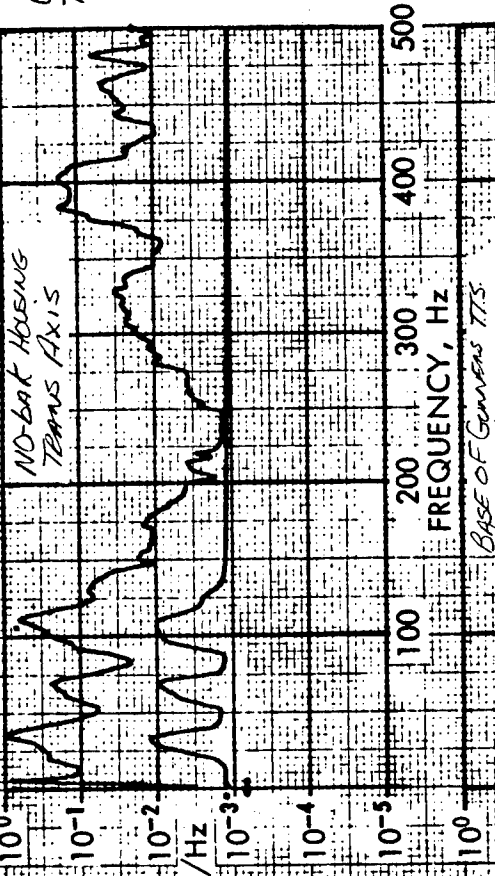


CROSS-COUNTRY
TEST PQ-2

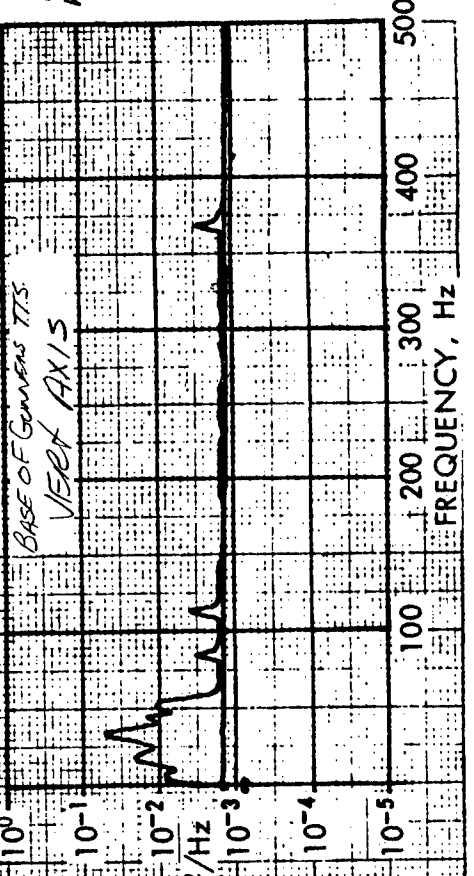
1 Low



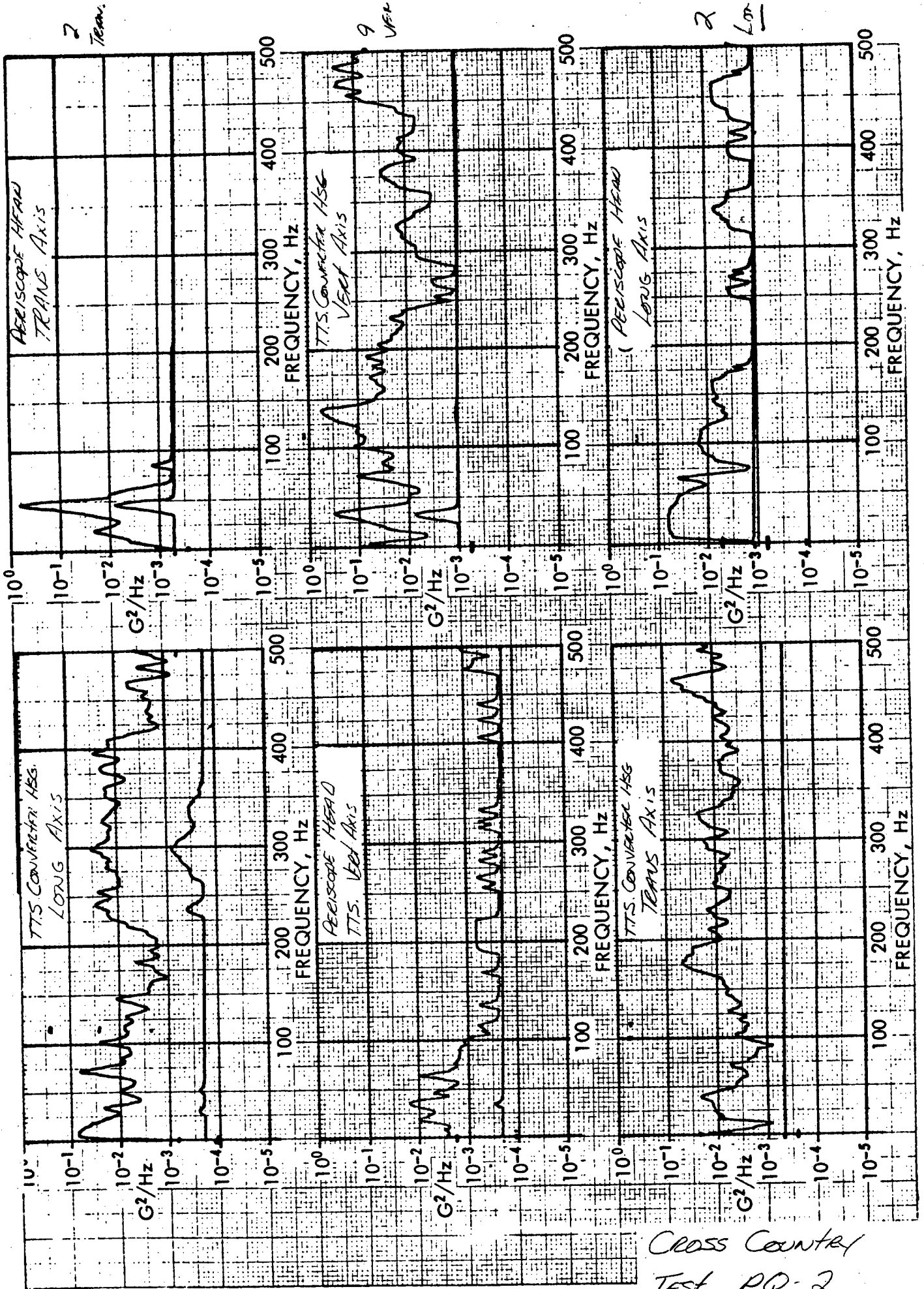
NO-BACK HOUSING
TRANS AXIS



BASE OF GUNNERS T.T.S.
VIA AX15

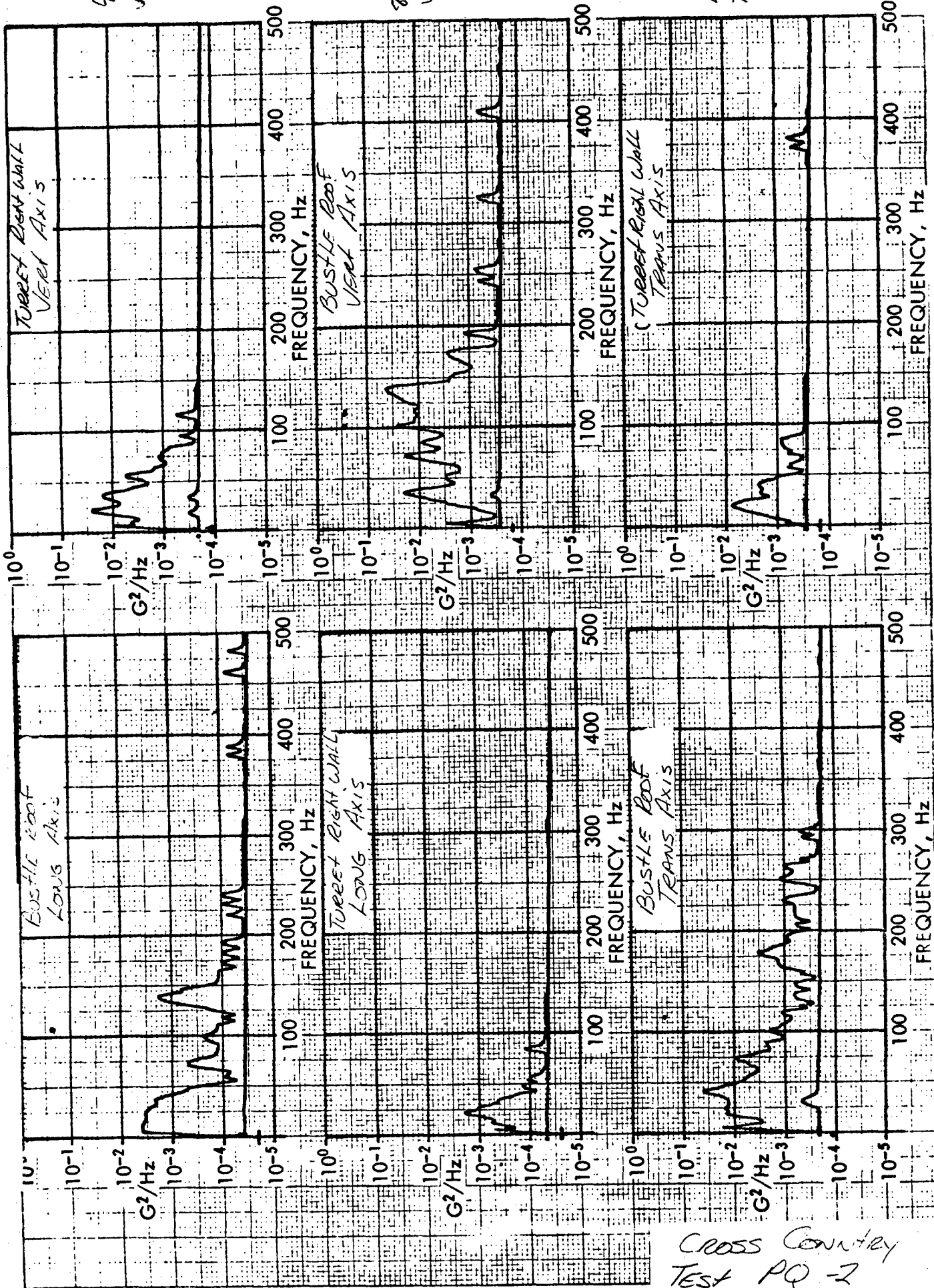


PQ-2 Cross Country 16 x 32



Cross Country
Test PQ-2

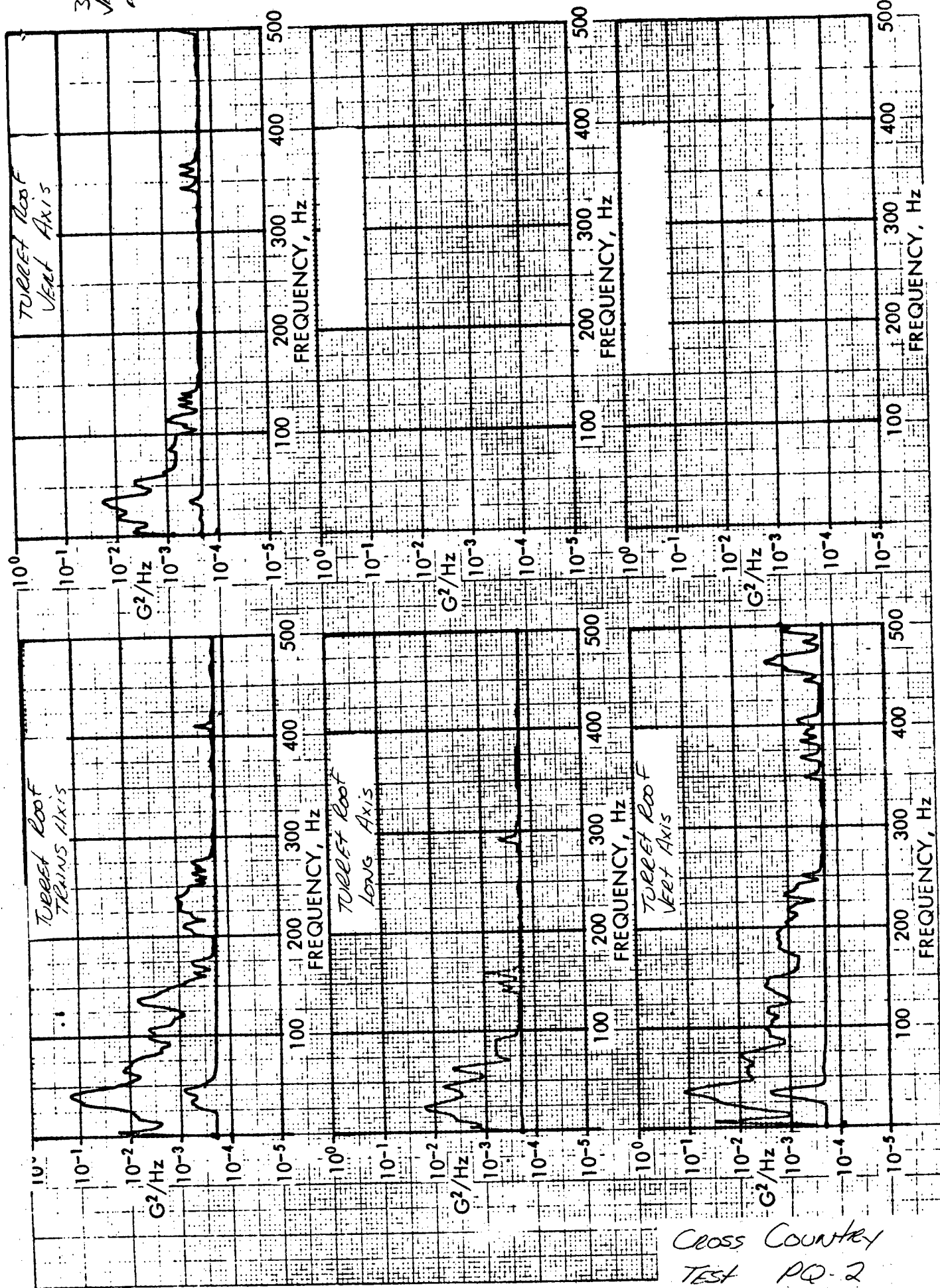
PQ2 Cross Country



Cross Country
Test PQ-2

PQ 2 Cross Country

3
JAN
1966



Cross Country
TEST PQ-2

3
Trans

3
Long

140

3
Vert



DEFENSE LOGISTICS AGENCY
DEFENSE DOCUMENTATION CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22314

IN REPLY
REFER TO

DDC-TC

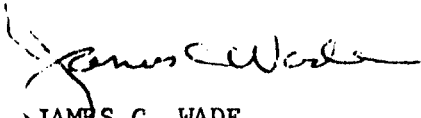
2 Mar 78

SUBJECT: Distribution Statement on Technical Documents

TO: Cmdr.
Army Tank-Automotive R&D Command
ATTN: RWL (Leon Burg)
Detroit Arsenal
Warren, MI 48090

1. DDC has received the report referenced below which does not carry an approved distribution statement per DoD Directive 5200.20 dated 24 Sep 70 (implemented by AR 70-31, NAVMATINST 5200.29 and AFR 80-45).
2. You are requested to indicate the proper distribution statement on the reverse of this letter. As a factor in your decision, reports should not be limited in distribution unless required for a valid and specific reason.
3. Request you forward your reply within 10 working days. Delay in responding will result in denying availability of this report to qualified users.

FOR THE ADMINISTRATOR:


JAMES C. WADE
Chief, Accessions Division

SOURCE: (Prepared by): Chrysler Corp, Warren Defense Division
TITLE: Supplement Test Report Gun Firing Shock and Road Vibration
M60A1 (P1) Tank Thermal Sight (TTS) AN/VSG-2 Prototype Qualification
REPORT NO.: Not cited.
CONTRACT/GRANT NO.: DAAK30-76-C-0005
DATE OF REPORT: 5 December 1977

FL-182
JAN 78